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NATURAL HISTORY OF TERMITES

I. THEIR GEOGRAPHY

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ALTHOUGH termites are very plastic in their adaptability to changing environment, only one species of termite (Reticulitermes) has world-wide distribution and lives in temperate zones having severe winters. Of the eighteen hundred known species of termites, only a fraction of them live in temperate zones; the rest are confined to a relatively narrow ecological zone in the earth's warmest regions.

The geographical distribution of termites is determined, to a greater part, by the minimum and maximum of temperature, for moisture and temperature are inseparable as environmental factors in termites. The United States has, for example, over fifty-eight species of termites, the greatest of any temperate region—a fauna that extends as far north as Canada and involves all but one of the forty-eight states in its depredations. This arises mainly because of the proximity of the United States to the rich Mexican termite fauna and still another factor: the tendency in North America toward central heating. Man here provides conveniently grouped, comfortably heated homes for wood-eating insects who would ordinarily succumb or withdraw when the temperature is less than fifty degrees.

Europe harbors two indigenous species and they have caused serious damage. All the southern provinces of France are involved, as well as Spain, Italy, Sicily. The British Isles are singularly free from the termite, as they are just below the mean annual isotherm of 50 degrees, which closely approximates the distribution of termites, which seem to succumb to any temperatures below this isothermal norm.

The reason for this geographical restriction is that termites have only a relatively thin and delicate integument, and lack the heavily chitinized exoskeleton of other insects and so are subject to bodily evaporation. Temperature—and thus the geographic distribution of termites—bears a relation to their sheltered life. Because of this readiness to evaporation they have become confined to structures which have more or less controlled temperatures. Even within their burrowings, the vulnerability of the termite to any temperature below fifty degrees is the deciding factor in their distribution. So, spectacular newspaper stories to the contrary, there is no sudden invasion of termites from the tropics, merely the adjustment of certain species present for millions of years to the changed environment brought about by man.

Confined to a narrow ecological range as they are, held by their frailty to their crypts, there is a natural limitation in

THE END OF A TERMITE ZONE IN THE HUMID SECTION OF ECUADOR

SOUTH OF THIS POINT THE LAND BECOMES A DESERT. THE AUTHOR IS EXAMINING THE LAST NEST, WHICH IS ATTACHED TO A MANGROVE OVERHANGING A SALT-WATER ESTUARY.

the termites' extreme diversification: there are only one hundred and thirty genera and seventeen hundred and eighty-five described species which, alongside of other orders of insects, is startlingly small. But what the termites lack in generic diversity, however, they make up in quantity, for they are of the most numerous insects in the hot lands.

Termite Architecture

As to be expected, the greatest florescence of termites is in the tropics. In Katanga, a Province of Belgian Congo, in North Rhodesia, termite mounds reach the incredible height of eight meters. In Africa, which has over five hundred species of termites, there are carton-building termites that construct immense nests in trees, other species that construct nests like giant mushrooms, and desert-dwelling termites that cover the scarce vegetation on the veldts and reduce it to hollow shells. There is another group of mound-building termites which cultivate fungus in the center of their mounds.[1]

The mounds of the termites are, perhaps, the most conspicuous feature of the African landscape. They are also on the savannahs of Paraguay and in the jungles of the Amazon, where, however, due to the frequency of floods, most of the termite nests are arborelous, or tree-dwelling types.

Australia has the distinction of having the tallest nests, termite spires that reach over thirty feet in height, and equally famous for their meridian tendency. Nests are found scattered over the thickly wooded sections, as well as the open country of Australia. The most curious feature of their architecture is their orientation to the direct rays of the

[1] These fungus-growers represent the most highly specialized members of the termite order, Isoptera. It is curious to remark that while there are fungus-growing ants in the Neotropics (New World), there are no fungus-growing termites, while in Africa and Indo-Malay it is quite the reverse.

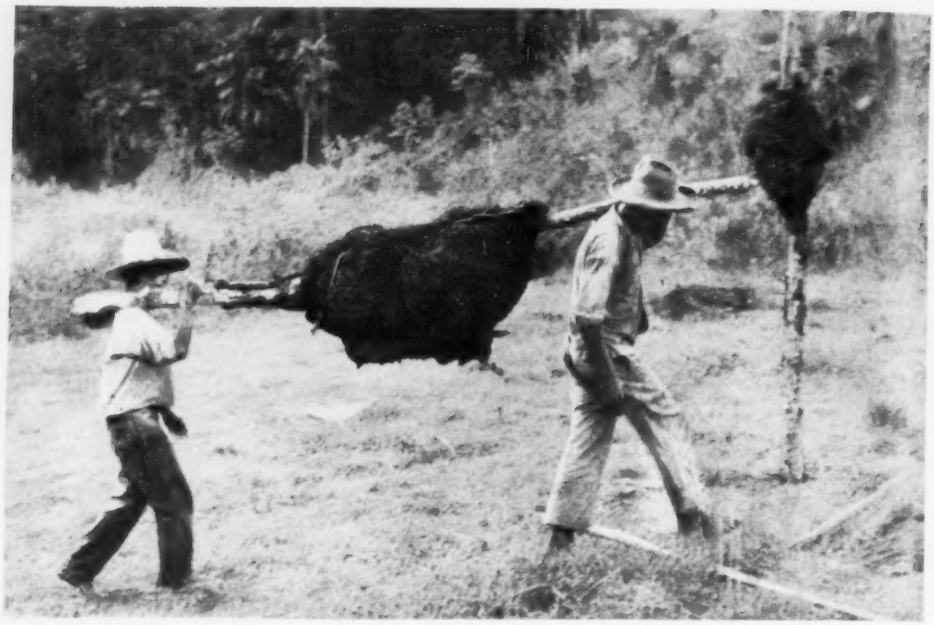
A TERMITE NEST IN HONDURAS

LARGE CARTON NESTS PERCHED IN THE CROTCH OF LIVING TREES ARE A FAMILIAR SIGHT IN THE WARM AND HUMID TROPICS.

H. L. Schantz

MUSHROOM-SHAPED TERMITE NESTS

IN THE HUMID JUNGLES OF THE AFRICAN CONGO THE *Mirotermes* CONSTRUCTS ITS NEST WITH A CAP SHAPED LIKE A MUSHROOM, THE ONLY PURPOSE OF WHICH IS TO SHED WATER.



NATIVES OF HONDURAS CARRY IN CARTON NESTS OF *NASUTITERMES*
THESE SERVED AS LIVING LABORATORIES IN EXPERIMENTS ON TERMITE REACTIONS TO LIGHT.

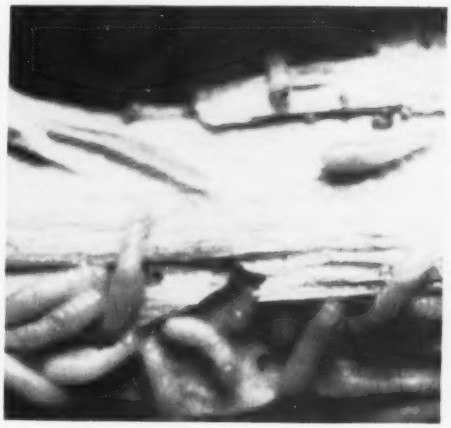
H. L. Schantz

TERMITE MOUNDS OF CENTRAL AFRICA OFTEN COVER AN ACRE
MILLIONS UPON MILLIONS OF INDIVIDUAL TERMITES MAKE UP SUCH A TERMITARY. THE NESTS OF AFRICA ARE MATCHED IN SIZE BY THOSE OF AUSTRALIA AND PANAMA.

sun. For a quasi-desert country, the termite population of Australia is very high, having over one hundred and fifty species. But whether the termites are found in Indo-Malaya, Africa or America, they all fulfil one important function: the breaking down of decayed cellulose into its basic chemical elements, which are returned to the soil. In fact, Drummond, the English naturalist, pointed out long ago that the termite in the tropics performs an important function analogous to that of the earthworm in temperate regions, but on a greater scale. Termites feeding wholly on dead vegetable matter conspire with the bacteria and humidity in order to accelerate the disintegration of all the lifeless wood which is converted into a humus and which, in turn, is utilized by the growing vegetation. It is thus that the termite fits into the teleological "scheme of things."

Dwellings of the mound-building termites can only be thorougly understood if one takes into consideration the miniscule insect that builds them, and one can only realize their immensity if one compares them with the achievements of man in physical relation to his own structures. If man built his buildings in proportion to those made by the termites, his tallest structure would be over 11,000 feet in height, about twice the height of the Schneekoppe in Germany or twenty times as high as the Washington Monument. If we take the average worker-termite as five millimeters in length, its buildings are 2,500 times the length of a single worker!

The structures of the termite of Africa have even given a hint to man for some new types of defense structures against air attack. The architectural features of the termite have even been suggested in the future planning of cities against strafing from the air. Each block in great cities would have a glorified termitarium, a mushroom-shaped building standing in a wide court. It would have



THE ENEMY OF WOOD EVERYWHERE
ARE THESE DESTROYERS, THE *Kalotermes*. WHITE, SOFTBODIED AND ARMED WITH SHARP DENTATED MANDIBLES, THE WORKERS CAN GO THROUGH THE HARDEST WOOD. THEY NEED NO GROUND CONTACT, AND THEIR COLONIES ARE USUALLY SMALL.

A TERMITE NEST OF THE AMAZON
THE IMMENSE SAVANNAHS BACK OF THE RIVERS OF THE AMAZON ARE SPOTTED WITH HILLOCKS WHICH HARBOR HUNDREDS OF DIFFERENT SPECIES OF TERMITES. MAN, BIRD AND BEAST EAT THE WINGED SPECIES IN THE RAINY SEASON.

a circular tower of some height, with a fusiform top shaped like the cap of a a giant termitary. The thickly made, windowless structure would have a series of rooms, each self-containing and, like the termite's realm, a sort of fortress.

But if the termites have shown man some factors in architecture, it is only inadvertently, for the real purpose of the nests is not only for defense, but they are also built thus because termites are soft-bodied insects, liable to evaporation. That, in addition to the ceaseless depredations by ants, has elaborated the termite fortresses. As the nests are airtight, heat is regulated so that the diurnal temperature in them varies only nine degrees; and so, to a certain degree, they control their environment, for on the outside the temperature may vary as much as twenty-five degrees. By this control, the correct amount of humidity is kept constant to forestall evaporation. However, there are some species, like the *Macrotermes* of Malaya, which, when the soil is wetted and the atmosphere thoroughly saturated, create conditions which allow them to take to the open. This the *Macrotermes* does in long, hurrying columns traveling between rows of soldier termites, always on guard against the attack of ants.

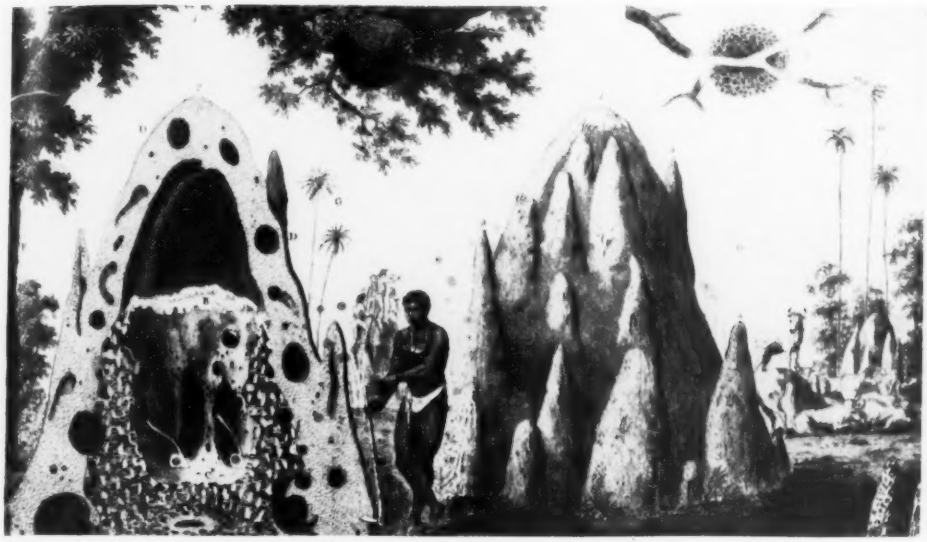
The termite "society" is a very old one. The habits of building its large termitaries that spot the landscapes of Panama, Paraguay, Africa and Australia are so ancient that a whole genera of animals, the Edentata, the ant-eaters, have become specialized in their evolution solely for the eating of insects, particularly termites. The ard-vaark of Africa, the scaly anteater of Indo-Malaya, the long-snouted giant ant-eater of Central and South America, have developed scythe-like claws in order to rip open these strong termitaries, and a long tongue, covered with a viscous substance to pull the hapless termites into its toothless jaws. All this implies for the termite a very ancient lineage, to have caused a group of mammals to become highly specialized just in order to rip open and feed upon the inhabitants of its steracoreous republic.

Fossil Termites

It is now generally accepted that termites began to evolve sometime during the Age of Reptiles. While the fossil records are by no means complete, it is rather certain that the ancestors of our present insect fauna had a long and varied history before the last part of the Carboniferous period. The termite, one of the more primitive of insects, rose from what is generally believed to have been the earliest form of insect life, the cockroach. From it, some believe, many insect forms have stemmed. The termites developed from a form of this cockroach, the *Proto-blattoids,* perfecting, after long evolution, a complex social organization.

Fossil termites are very well represented in the ambers from the Baltic, for the viscous resin from the Tertiary conifers caught some swarming termites and entombed them in it. Other termites, then distributed over a belt of modified tropical clime, fell into the soft slime of prehistoric mud deposits—the accumulating debris of volanic flows—and when this hardened into rock, the winged termites were preserved for posterity. Thanks to these varied methods of preservation, we have a very excellent idea of the development of the ancestors of the present-day termites. Yet the fossils tell us little or nothing about the evolution of the social state among the termites, for the fossil termites are similar in many respects to those found in the same regions of the earth to-day. It is therefore quite inescapable that the termite's social organization was perfected many millions of years ago, and that the multiple species that infest the world today have only perfected minor or insignificant changes during all these centuries.

A fossil termite, *Mastotermes*, is found,



THE FIRST ILLUSTRATION OF TERMITE NESTS

SMEATHMAN'S DRAWING OF 1781 ILLUSTRATES NESTS OF THE MUSHROOM-GROWING TERMITE, *Termes bellicosus*, OF AFRICA. NOTE THAT THE ARTIST HAS ATTEMPTED TO SHOW THE HEIGHT OF THE NESTS AS WELL AS THEIR DURABILITY BY DRAWING MEN AND CATTLE STANDING UPON THEM. SMEATHMAN'S REPORT ON THE TERMITES OF AFRICA, WHICH WAS GIVEN BEFORE THE ROYAL SOCIETY, WAS ONE OF THE FIRST OBSERVATIONS ON THESE REMARKABLE INSECT SOCIETIES.

AN ABANDONED TERMITARY IN AFRICA BECOMES A BRICK-KILN

MAN UTILIZES THE RESIDUE OF TERMITE ARCHITECTURE. BROKEN AND POWDERED, THE IMMENSE TERMITE MOUNDS CAN BE USED AS CEMENT WHEN MIXED WITH WATER. SOME INGENIOUS MAN HAS HOLLOWED OUT THIS TERMITARY NEAR ELIZABETHVILLE AND TRANSFORMED IT INTO A BRICK-KILN. GOLF COURSES ARE BUILT ABOUT THEM IN AFRICA, WHERE THEY SERVE AS "BUNKERS."

for example, in the Eocene and Upper Oligocene of England, which shows the same generic differentiation as a species of the genera found to-day in Australia. A study of the structure of the living representative of *Mastotermes* by the renowned Froggatt of Australia showed a combination of characters peculiar to cockroaches and characters that are common to termites so startling that the late Dr. Wheeler facetiously remarked that this *Mastotermes* has the same interest for the termitologists that the *Pithecanthropus erectus* has for the anthropologists!

There is yet to be revealed, from the geologic records, the rise of the social sphere among termites. Cockroaches, it is true, are quasi-social; but they are not differentiated into castes, nor does the life of the parent cockroach extend beyond the life of the developing insect, which would be necessary to reveal those

TERMITE DAMAGE IN THE TROPICS

ALTHOUGH THIS SEAT HAS BEEN IN CONSTANT USE AND IS MOVED ABOUT, THE TERMITES HAVE WORKED WITHIN THE CONFINES OF THE WOOD AND WILL GRADUALLY UNDERMINE EVERY INCH OF IT. THIS IS THE WORK OF THE GENUS *Cryptotermes*, WHICH NEEDS NO MOISTURE CONTACT.

TUNNELS PROTECT THE TERMITE

THE WHITE-BODIED *Heterotermes* OF CENTRAL AMERICA CONSTRUCTS TUBES IN WHICH TO TRAVEL TO THE JOISTS IT IS ATTACKING AS IT NEEDS MOISTURE CONTACT WITH THE GROUND.

extraordinary manifestations of organic cooperativeness that leads to the social form in insects. There are modern species of the cockroach that eat cellulose, the *Cryptocercus* in particular. Cockroaches also hollow out places for nesting and exhibit negative phototropic habits which makes them, like the termites, flee from light. None of the modern cockroaches, however, show any tendency toward the perfection of the social forms. No insect society can be successful without division of labor or a correlated specialization of structure and behavior. There is every reason to believe that the early predilection for wood by the primitive termites was not brought about wholly by choice, but rather by the depredations on the soft-bodied prototermites by the rapacity of ants which, though of a hymenopterous ancestry, were already present during the early developing periods of the termites.

Ants everywhere eagerly prey on termites. There are ants whose whole habit-cycle is built upon systematic attacks on the dwellings of termites, and species of

TERMITE NEST IN MEXICO

A COMMON FEATURE OF THE PACIFIC LITTORAL REGION OF MEXICO ARE THESE ARBOREAL NESTS OF THE *Nasutitermes*. EVEN THE AZTECS HAD A NAME FOR THEM—*tachinastl*.

ants that are conditioned in behavior to meet the curious defense mechanisms of the termite. In fact, the defensive factors of the termites have been perfected only for their one real enemy—the ant; their manner of living in closed burrows and the technique of the soldiers of throwing off volatile liquids in the form of gases or viscous latex streams are defences only against the systematic depredations of ants, so that, doubtlessly, the ever-present menace of ants has led to the evolution and perfection of the termite's cryptobiotic habits.

Almost the whole of our knowledge of the behavior of the termite is through its response to the abnormal. One must lay bare their burrows in wood, the hypogeums of the termitary, before the termite organization can be observed in flight or in performing tasks that it does only in abnormal emergencies. In a sense, some of its curious habits lead to its name.

Linneaus, the Swedish systematist, named the termite after "Terma," Greek for the goal, the end of life. The name of the insect which we now call the termite was confused with the deathwatch beetle, a form of the Anobiidae, which lives in furniture and is responsible for the worm-holes that perforate it. This beetle has a curious sexual aberation of knocking its head against the side of its burrowings, which results in a curious ticking noise. To the superstitious European peasantry, this was an evil augury of approaching death to some one in the household—hence its name, deathwatch beetle.

The larva of that beetle, a small soft-bodied white insect living in its cryptic burrows, was mistaken for the termite as it has the same soft, white body as the insect to which Linneaus gave the name "termite." "Terma"—the end or goal of life—is a ridiculous name for the ter-

TERMITE GALLERIES WORK HAVOC

WITH THEIR BORINGS PROTECTED BY THE STRONG HEAD OF THE SOLDIER, A COLONY OF THESE *Kalotermes* MAY REMAIN ALMOST "IMMORTAL," SINCE IN ADDITION TO THE FLYING REPRODUCTIVES THAT FORM NEW COLONIES, "BUDDING" TAKES PLACE WITHIN THE COLONY AS WELL.

H. L. Schantz

TERMITES CONSUME LIVING TREES

TERMITES ARE HERE DESTROYING WHAT WAS ONCE A SOUND EUCALYPTUS TREE IN AFRICA. THE RATE OF TERMITE DESTRUCTION OF LIVING PLANTS IN THE TROPICS IS VERY HIGH.

mite, as the queen termites are known to lay, during their life span, millions of eggs; it is certainly an absurd name-symbol for such extravagent fertility.

The admirable Smeathman, whose letter to the Royal Society in 1781 constitutes the first scientific report on the termites, described the gigantic termite structures in Africa. This information was received with incredulity by his colleagues of the eighteenth century. Africa was known to contain indescribable wonders, but Smeathman's report on insects that built enormous structures as much as 2,500 times the size of the workers, was a bit fantastic. Entomology, then, was suspect; it was, as the late Dr. Wheeler remarked, then regarded as a "form of concupisence, a *libido sciendi*, a *libido oculorum*"—an avertible peccadillo and a subtle and deadly temptation—perhaps the African sun had upset the critical faculty of Smeathman.

Travelers into Africa soon found that Smeathman did not exaggerate the industry, the social organization and, what is more, that he did not overestimate the depredations of these insects. Nor was this insectivorous destruction confined to Africa alone. The Spaniards in the New World found themselves at grips with this insect too. Houses were eaten away, the wooden base of their ordnance attacked and libraries destroyed. So consistent was the termite's love of literature, that in 1811 the famed German traveller Baron von Humboldt attributed the backwardness of the Latin Americans to the fact that they were unable to accumulate libraries, as the termites destroyed them as fast as they could be assembled.

The termite even caused a minor crisis in the none-too-stable government of King Carlos III of Spain. He had sent via Panama, toward the end of the eighteenth century, a shipment of gun-flints destined for Peru. The Viceroy in Lima patiently waited the arrival of the gun-flints and when they did not arrive, complained to the King's Council for this oversight. When the Governor of Panama was approached for an explanation, this administrator replied that the "commejens (the Spanish name for the termite) had destroyed all the crates and that the flints were lost in the dust. The King's Counselers, who did not know what a "commejen" was, issued a royal decree—still extant in the Library at Quito in Ecuador—demanding that the governor of Panama make a summary judgement on this *commejen*, compile a list of his grievous crimes against the state, and send him back under suitable guard to Spain, "Where he will be judged according to the result of his criminality."

(To be continued)

SWORDFISHING WITH THE HARPOON IN NEW ENGLAND WATERS. II

By Dr. E. W. GUDGER

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Dories "Punched."—In the first stage of the harpooning game, when the fish has been struck from the pulpit and swims away, he is tethered to the vessel and in by far the greater number of cases is on the defensive—though he sometimes does take the offensive to the hurt of the boat. Later when Xiphias has supposedly tired himself out dragging six hundred feet of sagging line and the attached keg about, one or two men are sent out in a dory to pull up alongside him and kill him by lance-thrusts in the gills. This may be all right for a grizzled old-timer, but when such an apparition emerges from the deep, a greenhorn doryman might well have qualms at the sight of the staring eyes and the massive sword.

At this juncture, however, the fish, "not very much resigned to die" (as it is put by the 1571 chronicler, quoted elsewhere for the Strait of Messina) not infrequently goes on the offensive, takes charge of the proceedings and launches himself against the dory to the great peril of the fishermen.

Innumerable attacks on dories must have occurred since swordfishing first began off New England nearly one hundred years ago, and of these but a small number have been recorded. Of this number I will quote here but a few, choosing those which are decidedly dangerous and from which if possible illustrations are at hand. Ordinarily the boat is "punched" through the bottom or side, but I have one unusual record where the sword went completely across the boat, piercing both sides.

In a case recorded by F. G. Hinsdale, a swordfish had been harpooned and, after it had supposedly tired itself out, Hinsdale and a fisherman went out to haul it in. When the line was nearly all in, it suddenly went slack. Thinking that the fish was gone:

> "Lost him," said Jimmy, in disgust, and the next second a thrill went through the dory as if it had been struck a sharp blow with a sledge hammer. There in the coil [of rope] just ahead of Jimmy's feet was some thirty inches of sword punched clean through the bottom. "Well, what do you know about that?" queried Jimmy with a grin, as, wrenching the sword backward and forward, he snapped it off short at the planking. Using the roller as a mallet, he drove the stub of the snout out of the puncture, through which the water welled like a spring until stopped with one of the canvas nippers worn to protect the hands while hunting. The fish, already exhausted and stunned by the impact, offered no further resistance and was readily taken.
>
> This is called "getting plugged." . . . Up to this time I have never fully answered Jimmy's query as to "what I know about it," but as I had been seated on the flooring astern, I know I am at least grateful that the fish elected to strike just where he did.

Now comes an account showing pictorially just what Xiphias can do with his broadsword. It happened to Mr. G. M. Phelps, Jr., who was out swordfishing off Montauk Point, Long Island, in August, 1936. A fish had been harpooned in normal fashion and line and keg had been thrown overboard. When it was thought that the fish had thoroughly tired itself, Mr. Phelps and one of the fishermen went out in a skiff to pick up the keg and bring the fish aboard. However Xiphias was by no means exhausted. When it saw the boat floating on the surface about fifteen feet away, it must have taken it for an enemy

or an object in some way allied to its present hurt. At any rate it charged the boat and drove its sword through a three-quarter-inch hard pine board in the bottom of it—fortunately without striking either of the men.

Then the fish in a frenzy lashed out and, after shaking the boat for some seconds and nearly upsetting it, broke off its sword, leaving the point extending diagonally through the splintered plank a distance of eighteen inches into the skiff. Seemingly exhausted by its efforts, and apparently subdued by the loss of its weapon, the fish allowed itself to be hauled aboard. The sword entered the board from the outside and split it longitudinally. The total length of the broken-off sword is 25.5 inches. The skiff, rendered useless by this mishap, had to have the old plank taken out and a new one put in.

If the sword penetrates a board parallel to the grain of the wood and splinters it, it may cause a considerable leak. Many leaking swordfishing vessels must have been struck like these two—with the grain of the wood—as was the little "sworder" "Redhot" of New Bedford in 1871.

An interesting attack took place on Georges Bank on June 24, 1937. It was described in lively fashion as follows, in the Boston Herald of June 28:

R. I. Nesmith

AN APPARITION EMERGES FROM THE DEEP

THE SIGHT OF THE LONG, DOUBLE-EDGED SWORD AND THE GREAT STARING EYE OF XIPHIAS WOULD SURELY EXCITE QUALMS IN AN INEXPERIENCED DORYMAN.

The swordfish was harpooned from the pulpit of the schooner "Andrew and Rosalie" . . . southeast of Block Island, June 24, and Isaac Boudreau went out in a dory to play it. For an hour and a half the big fish towed the little craft about in various directions, alternately leaping from the sea and sounding to great depths, and finally when the dory was three miles from the mother vessel, the fish dived and came up directly beneath the boat, piercing the bottom with its sword. Momentarily expecting the boat to be shattered by the struggles of the heavy fish, Boudreau signalled the schooner for aid. When the swordfish made no further movement, he realized that its attack on the dory had been its final effort.

Captain James Abbott of the "Andrew and Rosalie" confirmed this account and added further details:

Isaac was out alone, hauling in the keg and line, and when the fish got near the dory it suddenly turned toward it and rammed its sword through the planking of the bottom, the sword sticking through about a foot. Isaac, rather scared, had perched himself on the rear thwart of the dory and so escaped any possible injury. The sword broke off and the fish was soon captured. After the men unloaded their fish they cut the sword off, *i.e.*, the parts projecting inside and out, and the rest of it still remains in the dory. This natural plug saved them the expense of putting in a new plank.

This sword evidently penetrated the plank squarely, or at right angle to the grain of the board and hence did not open any crack. Thus the boat did not take in water. Boudreau's getting up on the thwart out of the way of the sword is standard procedure when it is seen that the fish is going to charge.

On July 10, 1937, one of the dories of the "Adelaide T." was "punched" off the northeastern end of Long Island. From Mr. John Maxson, the doryman concerned, I have the following vivid account of the encounter with his 350-pound Xiphias. Incidentally, the latter part of his story gives evidence of the enormous vitality of this stout-hearted fish.

We harpooned the fish off Easthampton, Long Island. But in the meantime we landed a very big fish which required much hauling and tugging for about an hour altogether. This took most of the pep out of me, so when we sighted another one about five minutes later, I vowed that this one was coming in fast—which he did to my regret.

I hauled on the line until he was about ten feet from me, when I let him tow me. This he did for about two minutes, when, without any warning, he turned and fastened his sword all the way into the dory at the water's edge. So I hauled in all the slack I could and tried to get his tail out of water, but he was plenty mad and made quite a fuss. So I signalled the big boat to come alongside, since in the meantime the dory was filling rapidly.

They came up and put a small steel cable around his tail and started to haul him in. However, he had other ideas and put up quite a fight but the power from a 60 h.p. Diesel engine was too much for him. Incidentally the reason for the great struggle was the fact that when we started to pull him aboard, we broke off his sword.

To haul such a great fish aboard a schooner, a loop of line is taken around the "small" of the tail and the fish is hoisted and swung aboard, sometimes by hand power but generally by a gasoline or Diesel engine. The next step in handling the fish will be described later.

Two accounts of swordfish attacks on dories during the season of 1938 have come to me through the assiduity of Mr. F. E. Firth, biological collector at Boston for the U. S. Bureau of Fisheries. One of these concerns not only the attack on a dory but the wounding of the doryman, and it will be found at the end of the next succeeding section. The other will be considered here.

Late in July, the schooner "Nyoda," Howard Tobey, owner and captain, was fishing off the northern end of Georges Bank. A swordfish was struck in the back and line and keg were thrown overboard. Presently Alphonse White was sent out to haul in the fish. It came along quietly at first, but as it got closer to the dory it put up quite a fight. Next it started driving straight at the boat, as though following the line. Then there was a thud and a splintering sound as the sword hit the dory and appeared through the planking and through a brace board on the inside.

G. M. Phelps, Jr.

SPLINTERED BOARD

A HEART-PINE BOARD FROM THE BOTTOM OF A DORY WHICH WAS SPLINTERED BY A SWORDFISH.

There are two things of particular interest in this account. The first is that the fish was struck not in the head but in the back, yet it went on the warpath. This agrees with Mr. Hand's dictum that in his judgment it makes little difference where a fish is struck, that one struck not in the head but in the back will sometimes, under conditions not well understood, attack a boat. The other is that this fish followed the line back to the dory and to the man pulling on the line.

Men Hurt in Attacks on Dories.—That swordfishing is a dangerous occupation has long been known. And with the multiplication of accounts of attacks on vessels as set out above, the reader has been wondering if the attacks on the bows (and forecastles) of sworders have not resulted in hurts, if not fatalities. However, since such attacks are made almost entirely in the daytime when the men are all on deck, no forecastle fatalities have been recorded. On the other hand, attacks on dories are only made when these boats have fishermen in them. There have been many narrow escapes from such attacks—some of which have been narrated above. But not always have the fishermen come off unscathed.

Earliest of all such cases, old Polybius in 100 B.C. recorded that swordfishing was a dangerous sport in his day, not infrequently resulting in wounds to the fishermen. Thus, as quoted by Strabo, he says: "It sometimes happens that the rower is wounded, even through the boat, and such is the size of the sword with which the galeote [swordfish] is armed, such the strength of the fish . . . that [in danger] it is not surpassed by the chase of the wild boar." None of the other classical writers, not even Oppian, who discourses at such length about Xiphias as an ocean gladiator, mentions the danger to the fishermen, although they do refer to the assaulted boats.

Coming now to our own waters, Captain Benjamin Ashby stated years ago that one of his crew was once wounded by the assault of a swordfish. The sword came through an oak board in the bottom of a boat on which a man was standing and penetrated about two inches in his naked heel.

Dr. C. H. Townsend, of the New York Aquarium, was once on a swordfish hunt off Block Island, when he found one of the crew of another swordfish vessel being taken ashore with a wounded leg. A fish had been struck and when the man went out to pick up the buoy and bring in the fish, Xiphias charged and wounded both the boat and the man.

Bigelow and Welsh, in studying Xiphias in the Gulf of Maine, heard of many dories which had been rammed without hurt to the fishermen. But they add: "We have . . . known several fishermen who have been wounded in the leg [in such assaults]."

More recently (July 5, 1937) Captain Alfred Cyr went out in a dory to retrieve a swordfish harpooned off Block Island. The fish charged the dory, ran its sword through it and wounded Captain Cyr slightly in the chest.

Another like mishap occurred in the Block Island region on the same day.

Mr. Paul C. Nicholson of Providence, R. I., was out swordfishing from his motor-sailer "Onza," when a swordfish was located. Put "onto the fish," Mr. Nicholson harpooned it—by a queer fluke—through the keel alongside the left base of the tail, as was found when the fish was brought in later. The buoy was thrown out and presently Mr. Nicholson and Captain Harry L. Smith went out to gather in Xiphias. But the fish, being merely tethered (practically not hurt), swam in wide circles offering much resistance to the "hauling in" efforts of the Captain, who remarked—"He's acting bad." But he had only begun, for suddenly he sounded, then coming up he rammed the boat from below. Just as Mr. Nicholson looked down, 18 inches of sword came through the bottom of the dory and the point cut a gash 6 or 8 inches long and about a fourth of an inch deep on the outside of the right calf. This was a narrow escape, and Mr. Nicholson writes "Had my foot been an inch or more to the right, I would probably have lost it."

The blow split a board in the boat's bottom, and with difficulty she was kept afloat until the "Onza" came up and rescued the men. The tethered fish resisted strenuously all efforts to bring him to the ship, and only after a conflict of two and a half hours was he got aboard.

In answer to a letter, Captain Smith writes that in 40 years' swordfishing he has had many dories punched. "We do not pay much attention to getting punched as it is a common thing to us fishermen." However, he tells of one bad accident. The sword came through the bottom of the boat just where a man was sitting and went through his thigh. He was taken to a hospital and fortunately made a successful recovery.

One account of a fisherman hurt in 1938 has come to me. This was recorded in the *Boston Post* of August 3rd. The "Evelyn G. Sears," Antoine Sears, master, was swordfishing on August first about one hundred and sixty-five miles east of Boston. A fish was harpooned in the head and a doryman, Frank Ferrara, was sent out to bring him in. When the dory was about fifty yards from the schooner, the maddened fish turned toward the boat and in a wild dash drove its sword through the side of the dory and then into the calf of the man's left leg, pinning him down until help arrived. When Ferrara was got aboard the schooner and it was found how badly hurt he was, Captain Sears called off further fishing to drive hard to get the wounded man to Boston and a hospital.

Mr. Firth, to whom I am indebted for these data, examined the fish and found that it weighed five hundred and five pounds "dressed"—*i.e.*, with head, tail and fins cut off and viscera out. This was a large and powerful fish. Its sword was, unfortunately, not measured but it is reported as rather disproportionately small for so heavy a fish.

Boston Herald

SWORD AND NEAR VICTIM

ISAAC BOUDREAU AND A SWORD LIKE THAT WHICH NEARLY FINISHED HIM WHEN HIS DORY WAS RAMMED ON GEORGE'S BANK, JUNE 24, 1937.

When a swordfish is brought up to the schooner, a loop is thrown around the tail, and it is hoisted aboard. But, if the fish is still alive, all danger is not yet over. So in order to prevent accidents it is necessary to cut off its sword. Then the fish is "dressed" before being lowered into the hold for "icing down." That there is a particular reason for depriving a not-yet-dead swordfish of its weapon is found in the following incident.

Mr. J. C. Zauner, who spent some weeks on a sworder, tells me that one day when a live fish was brought aboard, before its sword could be secured, the fish slashed out in a death flurry and with its weapon struck the captain on the leg. The sword sheared through the man's clothing and inflicted a five-inch cut in his leg.

This indicates the great vitality of this powerful fish. On this point Ralph Bandini writes (1933) more fully as follows: "Broadbill have not alone tremendous strength but unbelievable vitality as well. I remember one fish that was hooked and landed off Point Vincente [California]. He was loaded onto the deck of a launch and brought back to Avalon, two hours and a half away. When he was hoisted onto the pleasure pier there he came to life, wrecked the standard upon which he was hung and carried away a piece of the railing."

Men Killed in Attacks on Dories.—From the accounts of dories "punched" it is to be expected that a fisherman in a dory or skiff will occasionally lose his life when a swordfish makes its dangerous assault. Although a small number of fatal accidents due to swordfish are on record, only two such fatalities to New England fishermen in their dories have been found in an extensive search.

Early on August 9, 1886, the little schooner "Venus" sailed out of Lanesville, Mass., with Captain F. D. Langsford and a crew of three men. Here is what happened when, instead of harpooning a swordfish from the bowsprit of the schooner, it was done from the dory. This is the case of dory-fishing referred to previously.

> About 11 A.M. . . . a fish was seen. The captain, with one man, taking a dory, gave chase and soon harpooned the fish, throwing over a buoy with line attached to the harpoon, after which the fish was left and they returned to the vessel for dinner. About an hour later, the captain with one man took his dory and went out to secure the fish. Picking up the buoy, Captain Langsford took hold of the line, pulling his boat toward the swordfish, which was quite large and not badly wounded. The line was taut as the boat slowly neared the fish, which the captain intended to lance and thus kill it.
>
> When near the fish, but too far away to reach it with the lance, it quickly turned and rushed at and under the boat, thrusting its sword up and through the bottom . . . 23 inches. As the fish turned and rushed toward the boat, the line was suddenly slacked, causing the captain [who was hauling on it] to fall over on his back; and while he was in the act of rising, the sword came piercing through the boat and into his body. At this time another swordfish was in sight nearby, and the captain, excited and anxious to secure both, raised himself up, not knowing that he was wounded. Seeing the sword, he seized it, exclaiming, "We've got *him*, anyway!" He lay in the bottom of the dory, holding fast to the sword, until the vessel came alongside, while the fish, being under the boat, could not be reached. Soon the captain said, "I think that I am hurt and quite badly." When the vessel arrived, he went on board, took a few steps and fell, never rising again. . . . [and] survived the injury only about three days."

To prevent just such fatalities, Captain Harry L. Smith, of Block Island, writes that he formerly had a sheet of steel in the bottom of the boat for the boat-tender to stand on when hauling in the line. But he notes that "if the sword of a fish came through the boat and hit the piece of steel, you were likely to be knocked overboard. Once I was down off Nomans Land when a swordfish came through the dory's bottom, hit the steel plate, and knocked a man overboard and he was drowned."

The next and last account of an accident has a far happier ending and, for that reason among others, is given rather fully. It is the most extraordinary and unusual accident found in working up this history of swordfishing in New England.

A Man Dragged Overboard by a Wounded Xiphias.—There are in the literature many accounts of whale fishermen caught in harpoon lines and thus carried to their doom by diving whales. If the reader has perused any of these accounts, he must have wondered if occasionally a swordfisherman, trying to haul a fish up to his dory, has not also been pulled overboard by the superior strength of the fish, or has not had a foot caught in a coil of the retrieved line and thus been dragged overboard and down into the sea. Mr. Hand has recorded an account of a case of the latter kind.

On August 4, 1935, he was swordfishing from his yacht "Buckaroo," about thirty-five miles south of Nomans Land. A swordfish was sighted and struck, and keg and line were thrown overboard. Murray Pratt, "a giant of a man," was sent out in a dory to haul the fish in. The yacht cruised off about half a mile and presently it was noticed that the dory was floating bottom up and that a sloop nearby was making for it. The yacht ran for the dory and found two men in a skiff from the sloop supporting the limp body of Pratt, who seemed drowned, while the swordfish was thrashing about nearby. Fortunately a doctor was in the party and under his direction and help artificial respiration was tried, and in about an hour and a half Pratt was sufficiently restored to be carried aboard "Buckaroo" and taken to a hospital at Vineyard Haven, where he presently recovered enough to tell the story of his experience.

Mr. Hand had ordered that every doryman take with him in his dory a bushel basket in which to coil the line as it came in, so as to prevent such an accident. On this day Pratt went off without his basket and here is his account of what followed.

Gloucester Chamber of Commerce

ABOARD A SCHOONER

THE SWORDFISH'S PROTESTS DO NOT AVAIL AGAINST A ROPE LOOPED AROUND THE "SMALL" OF HIS TAIL, RUN THROUGH A BLOCK, AND WOUND AROUND THE DRUM OF A HOISTING ENGINE.

> I hoisted the fish up to the dory once but could not hold him. He ran off aways and then seemed to come along easily enough until I had him alongside again. Then he started for the bottom of the sea and I couldn't hold him. A turn of the line got round my ankle and over I went and down—down. I tried to kick the line free but couldn't get it off. Next I got out my knife, opened it and managed to reach down and cut the line. Then I started to swim to the surface and that's the last I remember.

One wonders that more accidents like this do not occur among the swordfishermen, since most of them simply throw the line in the bottom of the boat or at most make a loose coil of it there.

Fishing from Sport Cruisers.—The above accounts describe commercial swordfishing in the western North Atlantic, but of late years there has been developed a new style of boat for sport fishing. This is a gasoline-driven cruiser from which the sportsman either hooks or harpoons his swordfish. Here the equipment for such harpooning consists of a stout two-inch hardwood board securely bolted at its inner end to the deck and also to the stem, and further braced to the bow by iron struts or by a wire cable. At the outer end is a pulpit in which the angler or harpooner stands. The boat figured has a mast with a seat for a lookout, and a sail, in case the engine balks. However, many do not have a mast and the lookout sits in a chair secured to the cabin roof, or the harpooner acts as his own lookout. The board and pulpit are removable at will. Such boats as these are successfully used off Long Island and particularly at Montauk Point. It was from such a boat as this (Mr. Hand's "Buckaroo") that a swordfish was harpooned as described in the preceding section.

From another such cruiser, another swordfish was struck in the vicinity of Georges Bank sometime in August, 1928. Here is Captain Ira Abbott's interesting account and unique photograph of what happened.

> We harpooned the fish and sent a man out in a dory to bring it alongside the yacht. As the man in the dory seemed to be having difficulty in bringing the fish to the surface, I anticipated trouble of some sort, and was standing on the deck of the yacht with my camera all ready. When I saw the flash of the fish as it broke the surface of the water, I pressed the trigger of the camera with the result as you see it in the picture. An instant later, the fish gave a savage lunge and tore a large hole in the dory, causing it to sink. We got the man aboard the yacht safely and later succeeded in capturing the fish, which weighed 350 lbs.

The photograph referred to is unique in that it is the only one ever made (so far as I know) at the very moment that the swordfish pierced the side of the dory. In this figure is shown the right side of the stern of the dory with the sword protruding through a plank at about the water line. Below the sword is the left side of the fish's lower jaw dimly outlined in the water. Above is the line from the keg (already in the boat) leading to the shank of the harpoon under the surface of the water.

The next and last account of Xiphias harpooned from the pulpit of a yacht was kindly communicated by Captain James Abbott.

> We were cruising around off Montauk on July 12, 1937, hunting for swordfish, when our lookout at the masthead sighted a fish right ahead. The owner of the yacht ran forward to the swordfish stand and harpooned the fish. But unfortunately the harpoon struck forward of the dorsal fin and near the head. It usually happens that when a swordfish is harpooned in or near the head, it seems to go crazy and starts looking for something to attack. This fish came to the surface after the first plunge downward and started cutting circles around the boat. We went on to it again and a second harpoon was driven into it. Still the fish would not go down and I put out in a dory to play it. I hauled on the line from the keg till I got within about twenty feet of the fish. Then it suddenly turned and like a flash drove its sword clear through the bottom of the dory. Fortunately the sword did not strike me but that was just my good luck. After striking the dory, the fish thrashed about so hard that it almost threw me overboard and did break off its sword at a point just below where it went through the bottom of the dory. We secured both sword and fish and brought them into Montauk. The sword is the one I sent you.

Commercial "sworders," as indicated above, where depths of penetration of swords in their hulls are recorded, are very heavily built to withstand the terrific poundings they receive during "blows" on the Banks. Sport cruisers, however, are built to insure pleasure fishing. In a storm on the Banks, they would go all to pieces, and if the cruiser instead of the dory were charged by a hooked or a harpooned Xiphias, the damage would be very serious.

The Psychology of Xiphias

My readers have probably for some time been querying, "Why does Xiphias assault vessels, small boats and sometimes men?" Before endeavoring to answer, it will be necessary to study the mind of the so-called ocean warrior. It will not do to accept offhand the implication as to the character of our fish found in the names given him by the ancients. The Greeks called him Xiphias and the Roman Gladius. Both names mean "sword" and both are given him because the frontal bones of his head are drawn out into a long flat sword. We moderns call him *Xiphias gladius*, thus doubly emphasizing the fact that he is a sword-bearer. His common names in all languages emphasize the sword idea. Thus the Italians call him Pesce Spada, and the French name him Empereur, Imperator, Epée de Mer, and Espadon.

The Greek and Roman poets, whose knowledge of Xiphias was presumably obtained from the fishermen, and was at best superficial, were greatly impressed with his sword. They attributed to him a pugnacious nature. Earliest of all, Sophocles (496–406 B.C.) says of him:

> What Fury, say artificer of ill,
> Arm'd thee, O Xiphias, with thy pointed bill?

And Oppian (172–210 A.D.) speaks of Xiphias as "the sword-fish armed for war," says that the "hardy swordfish wields the threat'ning blade," and speaks of its "murd'rous use." Other ancients write in like vein of the fish and his weapon.

Modern writers, impressed by the apparently retaliatory attacks on the boats by the harpooned fish, have done their part to give him a "bad name." Thus in 1854 one writer said that Xiphias had a sword of a temper like that of its owner, and that neither was to be trusted. Another man alleged that the

Gloucester Chamber of Commerce

XIPHIAS IS DEPRIVED OF HIS WEAPON

THIS IS ALWAYS DONE PREPARATORY TO DRESSING THE FISH, BUT WHEN HE IS STILL ALIVE IT IS VERY NECESSARY SINCE HE MAY SLASH OUT WITH HIS SWORD AND WOUND A FISHERMAN.

fish was possessed of a "cholerie disposition." And finally G. B. Goode in 1883 said that "It surely seems as if a temporary insanity sometimes takes possession of the fish."

That these pronouncements are more or less uncritical and based on insufficient evidence, I will now endeavor to show. The evidence to be presented of the psychology of Xiphias comes from men who have long fished for and studied the swordfish. And it is mainly from those who from their knowledge of Xiphias gain a livelihood by taking him for food—from market fishermen. This evidence will first of all establish it as a fact that Xiphias is temperamental—if such an anthropomorphic term may be applied to a fish.

The Swordfish is Temperamental.—That this is true, has been incidentally noted above when discussing harpooning from the pulpits on the bowsprits of schooners. There it was stated that Xiphias is apparently afraid of a small boat but not of a schooner under full sail—though afraid of the shadow of her sails. He will allow a schooner to approach until her bowsprit is over him but he never allows the forefoot to strike him. Sometimes he moves aside like a playful dolphin but anon like a bad-tempered dog who has to get out of the way but who resents the necessity.

In further support of the opinion that the swordfish is temperamental, the evidence will be presented of two men who have for long years hunted this fish. Their experiences certainly establish the fact that Xiphias is very temperamental, and temperament in a fish of the genus *Xiphias*, as in a member of the genus *Homo*, is something likely to lead to trouble.

The first of these men—Bandini—had for seventeen years angled for the swordfish in California waters when he wrote in 1933 that:

Matthews Company

A SPORTS CRUISER EQUIPPED FOR SWORDFISHING

THE PULPIT IS OF LIGHTER CONSTRUCTION THAN THOSE IN REGULAR "SWORDERS." SOMETIMES THE MAST, WITH SAIL AND SEAT FOR LOOKOUT, IS LACKING. THEN THERE MAY BE A LOOKOUT ON THE CABIN ROOF, OR THE PULPITEER MAY SERVE AS HIS OWN LOOKOUT.

No two swordfish act alike. You never know what the particular one you may be hooked on to will do. . . . [He] is an individualist if ever there was one, who never does the same thing twice running, who may sound hundreds of feet and sulk there all day and all night, or who may charge your boat time after time, sword out, great jaws wagging, the picture of insensate fury, or who may leap in great awkward lunges, throwing white water ten feet into the air as he smashes back, or who may deliberately swim right up to your boat and calmly look you over as though he were determining by observation just what tactics he will pursue. . . . Personally I do not think they are vicious if left alone, but if hooked they will fight back and who can blame them.

My valued correspondent, Mr. Hand, who after 25 years' seeking for and studying Xiphias in New England waters writes of our temperamental and individualistic fish that, even when struck with the harpoon, in head or in front of the dorsal fin, one can not be sure what the fish will do. He may attack, he may try to escape by swimming away or by diving deeply. Of the free and unhurt fish he says:

On some days the swordfish are very timid, very easily frightened and very difficult to approach; on others they seem to be wholly indifferent and act as if they believed themselves "monarchs of all they survey." Like many other fishes, they seem to be more wary and more difficult to capture on easterly days, but there are exceptions to this rule also.

Corroboratory of what Messrs. Bandini and Hand have written as to the unpredictable behavior of the unwounded swordfish, certain data as to the like unpredictable behavior of the wounded fish will now be presented. Thus it is related that a fleeing harpooned fish when brought so close to the boat that he could see the splash of water round her forefoot, turned and sunk his sword in her bow. Another fish harpooned back of the dorsal fin, when hauled in toward the boat, whirled about and charged the bow full tilt driving his sword in it nearly up to his eyes. But that the wounded fish does not always attack the bow of the boat to which he is tethered but sometimes actually avoids the boat, is attested by the following account from Captain Oscar Johnson of the schooner "Edith Cooney." For it I am indebted to Mr. Firth.

A short time after it had been struck, one of the crew went out in a dory to haul the fish in and kill it in the usual manner. Every time that he hauled the line in, the fish would drive straight at the dory, and each time the man would slack off the line and the fish would retire. This being kept up for nearly four hours, the man became scared and finally came aboard the schooner without the fish. Capt. Johnson then brought the boat around to take in the fish, which had now become "public enemy No. 1," so far as the crew was concerned. As the line was hauled in, sure enough the fish dove straight at the schooner. But when only a few feet from the vessel it turned to one side and began to swim madly away from it, much to the amazement of every one.

Xiphias—a Timid, Not a Pugnacious Fish.—As shown above, the classical writers gave Xiphias a warlike name and a bad reputation and there have been many since who have declared that he surely has lived up to his reputation. But all along there have not been lacking those who have thought that the old adage of "a dog, a bad name, and hanging" applied to our fish, "armed as for war." Nor can it be denied that the combination of the long broad sword, and the huge staring eye (proportionally the largest in any known animal) do give Xiphias a sinister appearance. However, there are those who decry the idea of warlikeness and ferocity. On this point the testimony of experienced swordfishermen will now be given.

Since Xiphias has been hunted in the Strait of Messina from before the dawn of written history, testimony from that quarter will be welcome. This from L. Mazzulo, the chief Italian historian of this fishing, is very definite and positive. "It little, if at all, merits the name of a fiery and belligerent monster given it by the ancients; and it does not even attack the shark except to defend itself."

Since Xiphias has been sought as a food fish in our New England waters for over three-quarters of a century, with far more recorded retaliatory (?) attacks than the few off Messina, American testimony is very much in order.

It has long been said that swordfish sometimes go in pairs, presumably male and female, at the breeding season. But they never form schools, even when they temporarily collect in certain localities—presumably following the schooling fish on which they prey. But even before Goode's day (1883), it was known to American observers of the swordfish that these fish are solitary in habits, shy and easily frightened. Thus Goode (1883) quotes Captain Ashby that although 25 or 30 may sometimes be seen, two are rarely found together, and that they are generally at least 30 or 40 feet distant from each other. And many others since Goode's day have written that the fish do not go in schools, are timid, are easily scared, and that on some days it is very hard to get within striking distance of them.

This idea of the habits of the so-called warrior of the deep is commonly held by many experienced swordfishermen of the present day. This, Mr. Firth writes, is the testimony of Captain Ed. Smith and Mate Jud Stinson of the "Sunapee" who have been swordfishing together for 28 years. This is concurred in by masthead man Bill Conrad and chief striker Archie Stevens who have only been in the game a mere 15 years. Keen observers all, they agree that:

> The swordfish are perhaps the greatest cowards in the sea. In other words they are so easily scared that they jump away from each other when they happen to come in close proximity. Even a bit of floating seaweed may scare them away. They are not savage, but quite the opposite—they lean over backward the other way.

This then is the opinion of the innate character of Xiphias held to-day by practical commercial swordfishermen. These men, close observers, in constant danger both in vessels and dories of the "retaliatory" (?) attacks of our fish, do not think him vindictive in spite of his "bad name." But, says the reader—"You have set out above many cases in which the harpooned swordfish has sunk his weapon in schooners and has stove dories. How are you going to explain these? Are not these accounts conclusive evidence against the idea of timidity and for that of vindictiveness?" These questions I will now try to answer, both for schooners and for dories.

Why Does the Swordfish Ram Schooners?

A. H. Clark states, on the authority of many swordfishermen of his day (1886), that if a swordfish is struck behind the dorsal fin, he generally runs to windward, and rarely charges the vessel even though the line be retained on board. This same opinion is held by many New England fishermen of the present day. But if the fish is struck in the head or spinal column, he seems to go berserk, swims crazily in circles seeking for something to attack—as various of the swordfishing captains have stated in emphatic unanimity. Such a harpooned fish, as instanced above in many cases, is thus tethered by the harpoon line attached to the keg as yet not thrown overboard. His sphere of action is limited, the bow of the schooner being the center and the harpoon line the radius. The fish dashes wildly about in great pain and fright. The pain is located in the place where the harpoon head is implanted. The taut line leading back to the schooner pulls on the harpoon and localizes the source of the hurt. To ease the pain, the fish follows the line towards the source of the pain, and strikes the boat head on, generally in the bow.

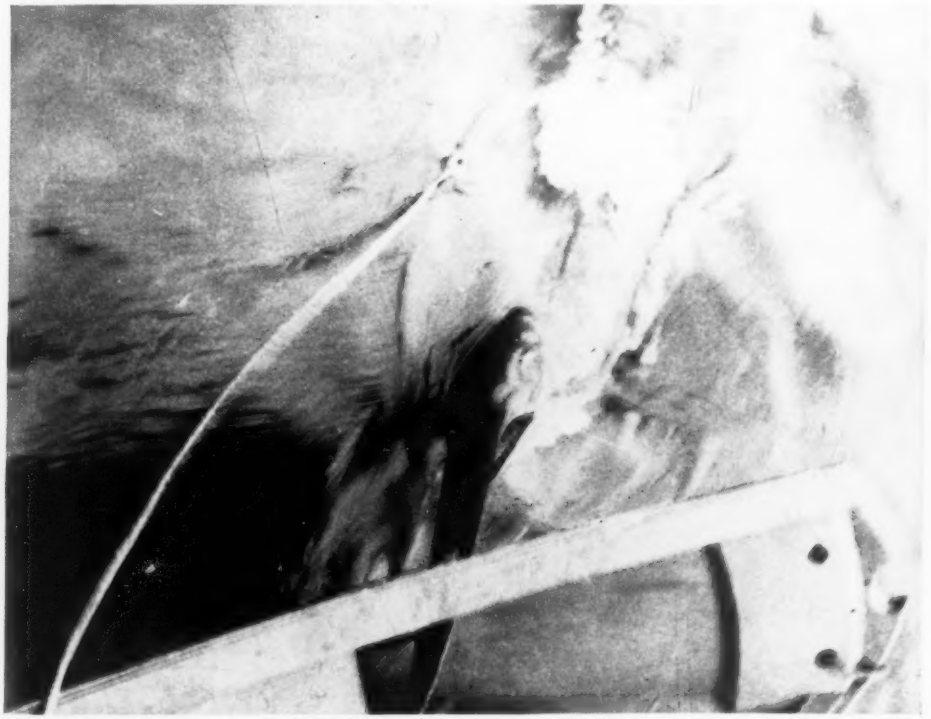
Mr. Hand has been quoted above that one fish, when harpooned from the pulpit, was headed for the vessel. The fish

came on at express speed following his original course and drove his sword into the vessel's bow. This automatic action is in my judgment the explanation for a certain number of cases of vessels struck in the bows. But for the great majority of cases, the explanation given in the preceding paragraph must hold.

Why are Dories "Punched" by Xiphias?

Ordinarily, when a swordfish has been harpooned, the line and keg are shortly thrown overboard and the fish is left to tire himself out hauling around the line with 600 feet of slack and at its end the keg, while the schooner goes in search of other prey. When it is thought that the swordfish has thus become sufficiently exhausted, a dory with one or two men is sent out to retrieve the keg by hauling on the line to bring boat and fish together so that he may be killed by lance thrusts in the gill region. He is then hauled aboard the dory or if too large is lashed behind until the schooner picks both up.

If the fish is harpooned back of the dorsal and is given sufficient time, he generally exhausts himself by swimming away and by deep diving. In deep diving with the head down, the fish does not see the line and hence there is no tendency to follow this back to the boat. Some fishermen put a weight on the line near the harpoon head to induce the fish to go down deep. Such a fish is almost always pulled up dead, "drowned" the fishermen call it. If a fish is not pulled in too soon (before it is tired out), he is not likely to strike the boat. But if the fish is harpooned forward of the dorsal fin and hence in the head or spinal column he "goes crazy," dashes wildly about and is liable to attack anything in



Captain Ira Abbott

A SWORDFISH RAMS A DORY

THIS IS THE ONLY PHOTOGRAPH KNOWN TO HAVE BEEN TAKEN AT THE MOMENT OF PENETRATION.

sight, whether schooner or dory. And any fish, wounded anywhere, is likely to attack if not sufficiently "worn down."

In an earlier paper (1938) I have given in some detail the testimony of various swordfishermen—captains, strikers and dorymen—that a fish struck in the head is always dangerous and that to pull such a one in too soon is almost surely to invite an attack. Perhaps I can not do better than to repeat here what I have said in that paper. "Even then (as Captain Ed. Smith puts it) the fish does not attack the boat but rather the warp line which is being hauled into the boat with the fish on it, and consequently the fish slams its sword into the boat." Most fishermen do not believe that the fish intentionally attacks the boat.

However, another view is held by Mr. Hand, who in 25 years' fishing has taken over 500 swordfish, and his testimony can not be passed over lightly. He states that he has never seen a fish deliberately attack a schooner or other large vessel, but that he has seen a number of swordfish apparently deliberately attack dories. In another letter he writes that:—

> Swordfish do deliberately attack dories at times. This I have seen with my own eyes on a number of occasions. I have seen fish try several times before contacting the dory properly to drive the sword through. There is not the slightest doubt in my mind that on occasions swordfish will attack dories. It is usually the smaller fish that do this. [On this latter point Captain H. L. Smith is in agreement] In my opinion it makes very little difference where they are struck.

The reader now has the proof that swordfish ram dories. The testimony is incontrovertible. But he still has the question—"In the face of these different opinions by dependable men of much experience in swordfishing, what conclusion can I draw as to the real cause of these attacks?" I have unfortunately never been swordfishing and I have never seen a dory rammed. But I have thought much over this conflicting testimony and have tried to form a conclusion of my own.

That a swordfish struck in or near the head (in the forward spinal column or brain) would have his nervous system disorganized and would lose its sense of equilibrium is readily understandable. That such a fish held by a line would gyrate around in circles with that line as a radius seems sure. That such a stricken fish when hauled in toward the dory, in order to ease the pain increased by the pull of the line on the harpoon imbedded in the flesh, would follow the warp straight toward the boat is readily understandable. That this fish, when close enough to perceive the boat ahead of it, would associate it with the cause of its pain and loss of freedom seems very probable. That it might conceive that the boat was an enemy which was responsible for its pain and detention, seems the most plausible thing in the world.

If these are sound conclusions, then we may go further and expect the attack to follow, and it would then look like a deliberate one.

SOLAR RADIATION AND THE STATE OF THE ATMOSPHERE

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For a week before the great aurora of September 18, 1941, with the attendant wide-spread disturbances to radio communication, the sun had been heralding the event. Although the sunspot cycle has been definitely on the wane since 1937, the week preceding the 18th presented one of the largest groups of spots seen in recent years, so conspicuous, in fact, that it was visible to the naked eye through suitable dark glasses. The forecasting of interruptions to radio communication is of increasing significance in these days of national defense, but the ability to foresee communication interruptions has been a recent result of intensified interest in the study of relationships between solar disturbances and terrestrial atmospheric conditions.

The sun is a typical star of rather ordinary proportions, but because of our proximity to it, the sun is the one star upon whose radiations activities on the earth are unalterably dependent. Military campaigns as well as agriculture since the dawn of civilization must be governed by the seasons for which the changing declination of the sun is the major astronomical factor. With the conquest of the upper air for transportation and the use of atmospheric electric waves for world-wide radio communication, the study of the sun's radiations in relation to our atmosphere has become an astronomical problem of far more than academic interest.

Not a day passes but that our United States Naval Observatory in cooperation with other observatories has a complete photographic record of the conditions of the sun's surface. When a huge solar storm is in the making, communication agencies are forewarned days in advance of probable periods of interrupted radio reception. The question of the relation of sunspots to the forecasting of weather is still in a controversial stage, but meteorologists are beginning to realize the increasing significance of conditions in the high atmosphere to the lower regions in which our weather appears to arise. All weather is fundamentally traceable to solar radiation. The amount and the character of this radiation, particularly in its relationship to atmospheric phenomena, merits more detailed consideration.

From observations at the Smithsonian Institution, the amount of energy that the sun emits has been measured with such precision that we know not only the quantity of heat and light emitted, but that this quantity varies from time to time by some 2 or 3 per cent. The average energy received by the earth from the sun is about 450 million million

William M. Kearons

FIG. 1. THE SUN, JULY 9, 1937, DURING PERIOD OF MAXIMUM SUNSPOT ACTIVITY.

horsepower. Because of the relatively insignificant size of the earth, and also the great distance that separates us from the sun a distance of 93 million miles, our planet can intercept but about one two billionths of the total solar output. Even so, if we stop to consider what the cost to us would be were we charged for a year's service of heat and light from the Solar Utilities Power and Light Company, we would find our indebtedness mounting to staggering proportions. At a price of $1\frac{3}{4}$ cents per kilowatt hour, the annual budget that would have to be allowed for sunshine for the continental United States alone would represent an expenditure of 327 quadrillion dollars. Such figures are indeed difficult to imagine. If we change our picture to a more restricted one, we can say that the cost of sunshine for Greater New York at the above figure would amount to approximately 100 million dollars for the average day. Fortunately for us, millions of years ago this same sunshine provided the energy for growing the vast tropical forests of the carboniferous era. The carbon in those fallen tree trunks that we are mining to-day in the form of coal together with the water power provided by the vast irrigating systems maintained by the sun's radiation is the source for the maintenance of our public utilities and industries to-day. It is an interesting question as to how long the sun could have maintained its present output of radiation and how far into the future we may rely upon its ability to furnish us with this all-essential source of energy. It appears probable that within the hot interior of the sun, which may be estimated in terms of millions of degrees, an atomic transmutation is taking place that has been going on for millions of years and is likely to continue for a long time to come. Through an ingenious carbon cycle recently worked out by Professor Bethe, of Cornell University, we picture the ultimate transformation of hydrogen into helium with the continual release of energy in the form of radiation that represents a loss of mass to the sun of some 4,200,000 tons every second. We scarcely need worry, however, about the deterioration of the fuel supply while the sun has about 2,000,000,000,000,000,000,000,000,000 tons of matter still left in it.

If we analyze the radiation from the sun we discover that it covers a wide range of wave-lengths. Certain of these wave-lengths or frequencies produce their own special effects upon the earth and its atmosphere.

We are all familiar with the fact that if sunlight is split into its component colors by means of a spectroscope we can see a large variety of the radiations represented by the various parts or colors of the solar spectrum. The visible range to which the eye responds represents frequencies extending from 400 million million cycles per second to a frequency just about double this, or 800 million million cycles per second. The sensation of the higher of these two frequencies is that of violet light, and the sensation produced by the 400 million million cycle frequency is that of deep red light. In between these two extremes of the spectrum fall the intervening colors. But outside this so-called visible range to which the eye responds there is a vast scale of radiations both beyond the red end of the spectrum, which we call the infrared, and far down below the violet, which we call the ultra-violet.

By means of the photographic plate, we can extend the map of the spectrum in either direction. Far out beyond the red end are heat radiations from the sun that may be measured with the thermopile or the bolometer. To-day much research is being done in measuring the extremely short waves, or high-frequency radiations out beyond the violet, for the ultra-violet is coming to have increasing importance not only from the

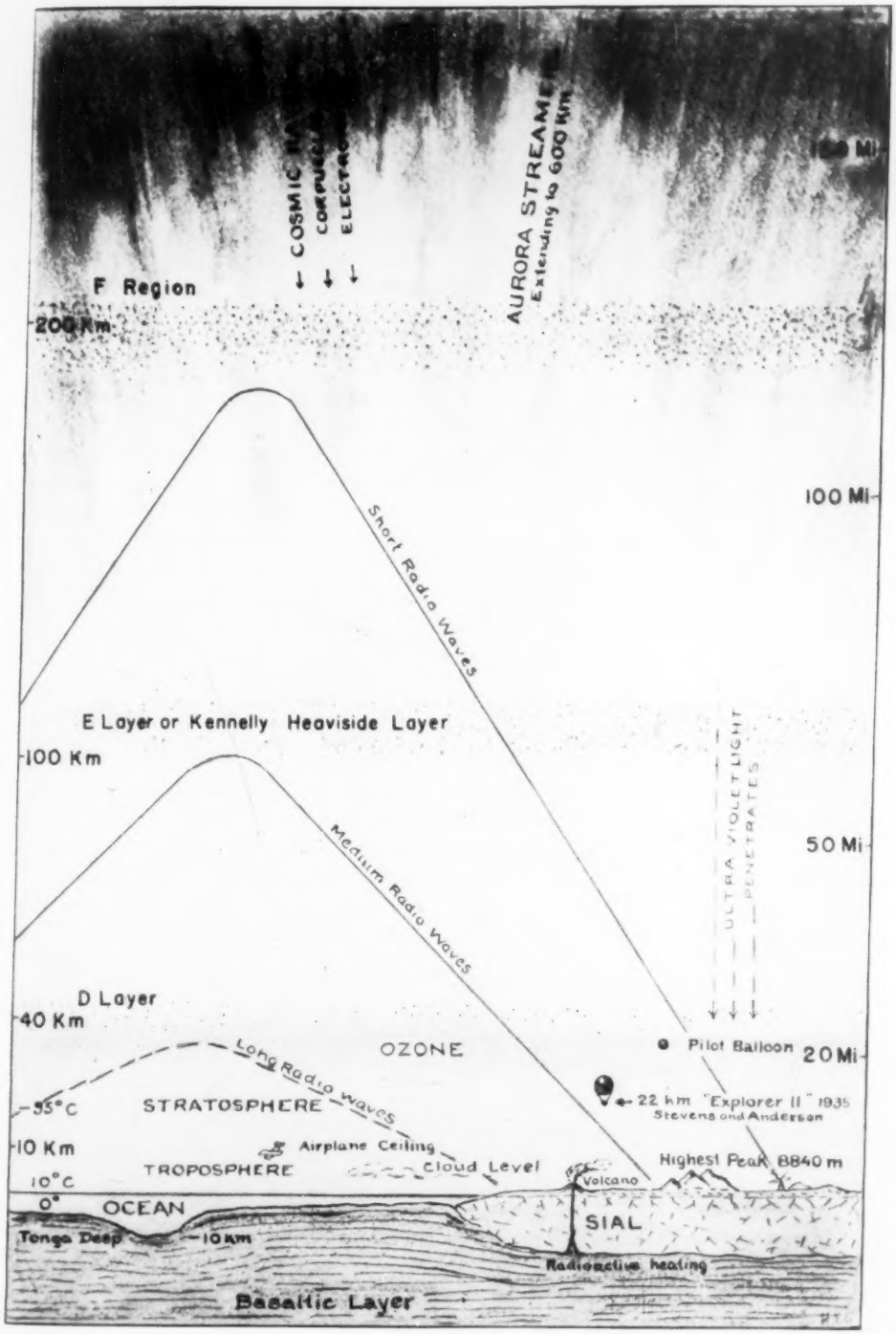

FIG. 2. CROSS SECTION OF EARTH'S ATMOSPHERE.

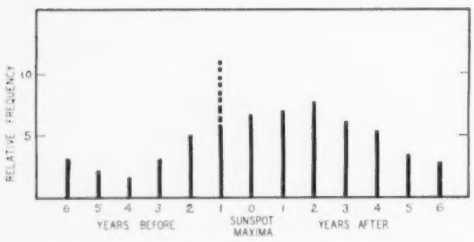

FIG. 3. RELATIVE FREQUENCY OF OCCURRENCES OF AURORAE AT THE BLUE HILL OBSERVATORY BEFORE AND AFTER YEARS OF SUNSPOT MAXIMA.

point of view of health but from the point of view of the radio engineer.

The sunlight which we measure or analyze at the earth's surface is, however, seriously modified by the absorption introduced by the constituents of our own atmosphere. As we all know, the earth's atmosphere consists of nearly $\frac{1}{4}$ oxygen and $\frac{3}{4}$ nitrogen. There is a sprinkling of carbon dioxide with a bit of argon, neon, crypton, xenon and a trace of helium. Here at the earth's surface we can count on a little more than 1 per cent. of water vapor. For a thorough mixing of the elements of this atmosphere and the maintenance of its temperature as well as the variation in its temperature, we rely upon the sun. Occasionally we have vividly impressed upon us the relationship of our atmosphere to disturbances on the sun, by displays of aurorae or the Polar Lights, often flaming gorgeously red and stretching 100 miles above the earth. These glowing electric discharges advertise the lofty air swarming with the traffic of electrons, ions and particles, jostling one another as they are excited by radiations from the sun peculiar to the occurrences of sunspot activity.

Observations with the spectroscope indicate that there is much radiation at the extreme ultra-violet end of the spectrum to which the earth's atmosphere is completely opaque. A great deal of the absorption of this region of the solar spectrum of very short wave-lengths is caused by a layer of ozone which exists at an average height of about 22 kilometers, but which probably occupies a region extending from 15 to 35 kilometers. If all the ozone in this region were to be brought to the standard conditions of temperature and pressure of our atmosphere at the earth's surface, it would represent a layer of only 2 to 3 millimeters in thickness. Yet this small amount of ozone is the defense between us and extremely dangerous radiations in the ultra-violet region of the sun's light. Were the absorption, however, of this region of the solar spectrum even a little greater than it is, we should be deprived of that small amount of ultra-violet light filtering through our atmosphere that is so essential for health and the production of our sunshine vitamin D. Whether or not variations in the sun's radiation are sufficiently great or changes in the absorption of the earth's atmosphere sufficiently large to bring about dangerous variations in the production of vitamin D in living organisms at the earth's surface is an interesting question for speculation and for investigation.

We can be confident, however, that it is a fortunate combination of the sun and our atmosphere that makes life on the earth possible. The sun not only radiates its health-giving sunshine, but it also emits literally death-dealing rays. Were it not for the protecting shield of the earth's atmosphere, the sun would be the annihilator of us all. The atmosphere provides on the one hand oxygen for maintaining life, and on the other hand protects us from the highly penetrating rays. It is a sort of a buffer state, the very top of which receives a violent bombardment of high frequency radiations from the sun, and the lower layers of which form a blanket that enables the earth to retain during the night much of the warmth generated by the sunshine that has penetrated through

it, thus mitigating the extremes of temperature between night and day to which the earth would otherwise be subjected.

If we look at a cross-section of the earth's atmosphere, it may for convenience be divided into three zones or layers in which the stratosphere occupies the middle ground. The region below the stratosphere is that which contacts our immediate surroundings and provides the winds and atmospheric currents, giving rise to all our weather. We call this lower region comprising perhaps the first 5 or 6 miles the troposphere. The region above the stratosphere is the ionosphere. If we send a recording thermometer aloft, we find that while passing through the troposphere the temperature steadily falls until a height of 10 or 12 kilometers is reached, when the temperature reaches the extremely low value of $-55°$ C., or some 68° below zero Fahrenheit. Strangely enough, for the next 30 miles or so there appears to be little change in temperature. This is the region of the stratosphere. The weather forecaster for the stratosphere would have a relatively simple task, for day after day, year in and year out, his prognostications would be "clear and cool," and his forecasts would be 100 per cent. correct. At a height of 60 kilometers or some 40 miles, the temperature would begin to rise again. Recent investigations give some evidence that at extreme heights, up where the auroral fires play, temperatures of 1,000° C. have to be postulated to account for the presence of the ionized oxygen that is there. The extremely rarefied condition of this upper atmosphere, however, calls for perhaps a quite different interpretation of temperature than that to which we are ordinarily accustomed when determining temperatures by the thermometer at the earth's surface.

Ascending through the cross-sections of the atmosphere, we find there is a rapid decrease in the amount of atmospheric pressure. Within the first 3 miles from the earth's surface, half the total amount of oxygen and nitrogen, the principal atmospheric ingredients, are included. The limiting height to which the thinning atmosphere extends is somewhat difficult to fix. Perhaps we should place it at 200 to 300 miles, although recently Dr. Carl Störmer has observed auroral streamers reaching to heights of 600 kilometers or more. Where auroral streamers go, some of the thin atmosphere must extend.

If we make a chart of the numbers and occurrences of aurorae we find there seems to be a curious connection between the frequency and brightness of auroral displays and the state of the sun as marked by the appearance of sunspots. Professor Brooks, director of the Blue Hill Observatory, has kindly allowed me access to the records made of aurorae at that station for the last 30 years. Utilizing the observations of the brighter aurorae, we may make a graph showing the variations in the auroral frequencies occurring in years distributed with respect to the maximum occurrences of sunspots. The fewest number of aurorae appear to occur from 4 to 6 years before or after the years marking sunspot maxima. The time when aurorae appear most frequently would seem to be about 2 years after the passing of the maximum of sunspots. These results corroborate rather well those of a longer series of observations tabulated by Dr. Chree extending for over 100 years, or from 1750 to 1877.

The fact that aurorae occur with far greater frequency during years when sunspots are more numerous than during the years when there is a scarcity of sunspots suggests that the electrical effect in the upper atmosphere is something for which a disturbed solar surface is responsible. There is, I believe, a good reason for the fact that the maximum in the auroral displays occurs a year or two after the year of most sunspots As sun-

spots begin to wane in numbers, they are nevertheless occurring in regions progressively nearer the solar equator, and as the sun's equator is inclined but slightly to the plane of the earth's orbit, we may draw the inference that sunspots are most effectively associated with the occurrence of aurorae when, other things being equal, they are most nearly in the geometrical plane that the earth travels in its journey around the sun.

Much of our present knowledge of aurorae is due to the exhaustive studies and mathematical calculations of Dr. Störmer, of Blindern, Norway. By careful analysis of the motion of charged particles in the magnetic field of the earth, he has been able to deduce tracks of ionization so simulating auroral forms as to indicate very significantly that such discharges in the upper atmosphere are indeed the result of bombardments of electrons coming in from outside, warped by the magnetic field of the earth. In endeavoring to express such phenomena on an electronic hypothesis we may well look at the sun, therefore, for a consideration of the character of sunspots and so trace any possible mechanism by which corpuscular charges might be ejected in the region of the sunspots themselves.

When we look at an enlarged view of a sunspot and analyze the light from it, we find that the dark interior center is surrounded by a turbulent area. Photographs taken in the light emitted by hydrogen at a particular frequency reveal that there are whirling masses of gas, arranging themselves in veritable vortices. There is every indication, then, that a sunspot is in reality a terrific solar hurricane. It was in 1908 that the late Dr. George Ellery Hale, the founder and director of the Mount Wilson Observatory, first observed that sunspots were giant cyclones in the sun's atmosphere. They are indeed very similar in their formation to the tropical hurricanes that originate in the West Indies and sweep northward.

With photographic emulsions made especially sensitive to the red light emitted by hydrogen, there may be photographed on a moving film the entire solar surface so far as it is covered by bright luminous hydrogen clouds. The resulting representations of the sun appear very different from photographs made in ordinary light. Not only are large clouds of hydrogen gas discernible all over the sun, but in the neighborhood of sunspots they often seem to be swept into the heart of the spot as if they were caught in the center of a whirlpool. Such an appearance might be presented by the top of a terrestrial cyclone or tornado if photographed from a stratospheric balloon. The dark center of the spot forms the center of the vortex; the outlying shaded region that characterizes the so-called penumbra of the sunspot would represent the turbulence bordering upon the central funnel about which the atmospheric particles are rapidly rotating. Thus we see there is a close analogy between the meteorology of tropical cyclones and that of sunspots. To carry the analogy still further, spots north of the sun's equator are in general whirling in one direction while corresponding spots south of the equator whirl in the opposite direction. If the rotation of the one is clockwise, that of the other is counter-clockwise. This again is characteristic of the differences of rotation of tropical hurricanes on the earth originating in the northern and southern hemispheres, respectively.

Had it not been for the trick of splitting up sunlight into isolated frequencies by means of the spectroscope, we should never have had pictures showing the existence of solar vortices such as we have to-day. In the ordinary photograph of the sun, the light emitted by every chemical element in the sun's atmosphere is clamoring to tell its story.

The result is revealed in a rather jumbled picture of what is happening on the sun. The spots show up as dark regions only when the light-emitting power of every element of the sun is damaged in the vicinity of these violently disturbed regions.

The spectroscope is very much like a highly selective radio receiving set. The sun is a high-powered station sending out light, broadcast in all the wave-lengths and frequencies. When we look at the sun or photograph it with a telescope alone, we are using all the light and are, so to speak, operating a radio receiver which admits all frequencies at once. Thus we get a composite but very jumbled picture of what is happening on the sun's surface so far as details are concerned. By means of the spectroscope, however, the photographic apparatus, to continue our analogy, may be tuned to a single frequency such as the 470 million megacycle frequency that the red line of hydrogen emits. Tuned to this frequency the spectroscope stills the tumult of all other elements and lets hydrogen tell its own story. It is then that we obtain the clear photographs conveying so beautifully the detailed information about the vortical whirls around the solar storm centers that would otherwise be lost in the jumble of too many story-tellers.

It has long been known that the frequencies of light waves are distorted if there is a powerful magnetic field surrounding the light source. This had been demonstrated in the laboratory shortly after the reason for such a phenomenon had been given by Zeeman in 1894. When the Mount Wilson observers first examined and actually measured the frequency of light coming from the centers of sunspots, it was found to have changed frequency in exactly the way that light waves are distorted in the laboratory when a powerful electromagnet is placed around the source of light being examined. If additional proof were needed for the explanation of the changed frequencies, it may be stated that the double and triple lines found in the spectrum of sunspots indicated that the light was polarized just as in the case of the polarized light waves coming from the laboratory source upon which the magnetic field is impressed. Thus came the startling revelation that sunspots

FIG. 4. APPARATUS USED IN RECORDING CONTINUOUS NIGHTLY FIELDS FROM WBBM CHICAGO AT NEEDHAM LABORATORY.

were not only terrific hurricanes but every center was in itself a powerful magnet. Since a magnetic field may exert a repulsing effect upon swiftly moving electrons, we see some reason that charged electric particles can be actually hurled from sunspot centers at velocities which may carry them through space into the earth's atmosphere, thus ionizing the upper regions of the air in a way that would produce auroral displays. In

the light of such a mechanism, therefore, we see a possible reason why aurorae occur in greater numbers and at greater brilliance at times when these solar storms occur most frequently.

With the new unsurpassed equipment installed at the McMath-Hulbert Observatory of the University of Michigan, motion pictures of the sun's surface have been made on many different frequencies of the sun's radiation. These cinemagraphic records promise more material for the intense study of the behavior of the solar surface than has ever before been available. Some of the movements in the high solar atmosphere over the regions of sunspots revealed by this new process of recording continuous motion at present defy explanation and may yet completely revolutionize our ideas of the sun's behavior pattern.

Perhaps the terrestrial effect that has most nearly paralleled the sunspot cycle is the variation in the state of the earth's magnetic field. For over 100 years, it has been definitely known that the direction of the compass needle and the intensity of the earth's magnetic field show definite relationships. In the years when sunspots are most numerous magnetic disturbances are most frequent and appear with marked intensity. The years when sunspots are most numerous follow with more or less regularity an interval of somewhat over a decade between the times of maximum sunspot activity. This solar cycle, or sunspot period as we sometimes call it, is usually conceded to be on the average of about 11.3 years duration. An examination of a graph will show that sometimes the interval between maxima may be as short as 9 years and on occasion as long as 17 years.

The last maximum of sunspots was passed in 1937 and we are well on our way on the down side of the cycle. It was not until the more recent discovery of an ionized region in the upper atmosphere of the earth that any real explanation appeared as to why sunspots and changes in the earth's magnetic field should show so close a parallelism.

Every one knows in a general way that the earth is a magnetic sphere. That the compass needle does not point true north except in various restricted parts of the globe is also a fact which is generally recognized. Perhaps comparatively few who are not geomagneticians realize that the compass needle is constantly wandering back and forth every day by a slight

FIG. 5. NEWLY ESTABLISHED LABORATORY FOR COSMIC TERRESTRIAL RESEARCH IN NEEDHAM, MASSACHUSETTS. THE RESIDENCE OF THE DIRECTOR IS IN THE BACKGROUND AT THE RIGHT.

amount. When the sun rises in the east, the north end of the compass needle turns slightly toward that direction. By noon when the sun is south, it is pointed in its normal position. Then in the afternoon as the sun wanders and sets in the west, the compass needle wanders likewise to the west, coming back again to its normal position about midnight when the sun is below the northern horizon. This goes on day after day, month after month—but during the years when sunspots are most numerous these daily excursions of the compass needle will on the average be twice as great as during the years when sunspots are lacking. These diurnal wanderings of the compass needle can now be roughly explained as due to the effects of ionization of the upper atmosphere by sunlight. As the electric charges become separated in the process of ionization of the molecules of nitrogen and oxygen under the bombardment of ultra-violet light from the sun, the movements of these ions create a perceptible current, deflecting the compass needle from its normal magnetic position. We may infer, therefore, that at times of sunspot maxima the number of these ions in the upper air is materially increased, producing a more marked magnetic effect. The strength of the magnetic field of the earth, therefore, may be considered as increasing and decreasing with the variation in the intensity of the ionization of the upper air that changes with sunspot occurrences. Most of our knowledge of the ionized region has come about through the invention of radio.

In the early days of wireless, it was thought that electric waves which carried telegraph messages without wires traveled in straight lines over the earth, just as light waves do. With this conception one could never hope to communicate over very great distances, since the curvature of the earth would prevent the passage of the waves as the earth's

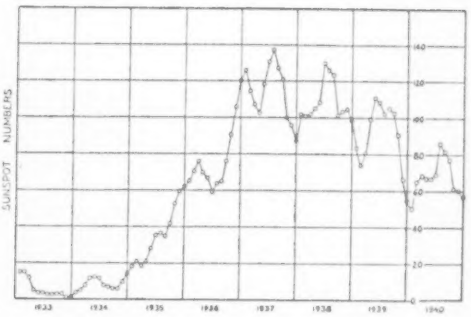

FIG. 6. THE TREND OF SUNSPOT ACTIVITY HAS BEEN DEFINITELY DOWNWARDS SINCE 1937. CURVE OF SUNSPOT NUMBERS SMOOTHED BY THREE MONTHS MOVING AVERAGES.

huge bulk bulged into the communication path. The earlier wireless engineers thought that only by building higher and higher antenna towers could one ultimately hope to communicate over the thousands of miles that would make trans-oceanic wireless possible.

Of course, these early crude notions about the way in which electric waves travel were erroneous. Such, nevertheless, is the way in which science has groped into the unknown. Somebody experimenting with wireless and listening in found himself quite unconsciously eavesdropping on Marconi waves from the other side of the Atlantic. Instantly the thought about how wireless waves travel had to be changed. Evidently the electromagnetic waves followed the curvature of the earth and did not travel in straight lines after all. This led Professor Kennelly of Harvard to postulate that there must exist high above the earth's surface, perhaps 100 miles or so up, an electrified conducting layer from which the electromagnetic waves emitted from the powerful antennae were reflected back to earth. The earth's upper atmosphere, therefore, in his mind formed a conducting layer and imprisoned the radio waves between the earth's surface and space outside. A few months after Professor Kennelly published his hypothesis, the English

scientist, Oliver Heaviside, announced a similar conclusion quite independently. In honor of these two distinguished men this upper region of the earth's atmosphere that is electrically ionized is commonly referred to as the Kennelly-Heaviside layer, also designated as the E layer.

If we look at a diagram which presents a vertical section of the earth and its atmosphere, we see that this Kennelly-Heaviside layer exists at an altitude of from 100 to 130 kilometers. Radio waves emitted from a sending station in all directions arriving in this ionized region have their velocity and direction changed as they penetrate further and further into the region, until at length they are bent back to earth again, reaching receiving stations hundreds and sometimes thousands of miles from the source whence they were broadcast. This region lies far above the stratosphere and generally above the region that is usually regarded as that where ozone is manufactured. This E layer is particularly favorable for reflecting or turning back radio waves of the frequencies which are most generally used for commercial broadcasting in connection with our entertainment programs. Radio waves of much shorter wave-lengths or of higher frequencies penetrate and actually traverse through this region until they reach what appears to be another ionized region called the F layer, originally postulated by Professor Appleton in England. This F layer lies some 200 kilometers high or in the territory where auroral streamers stage their gorgeous displays. If the ionization of these upper regions is more intense as we near the period of maximum sunspot activity, one might well expect that some change might be observed in connection with radio transmission.

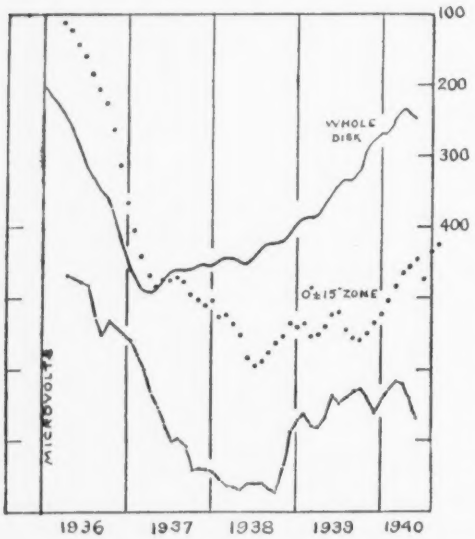

FIG. 7. TREND OF RADIO FIELD STRENGTHS OF WBBM RECEIVED IN BOSTON COMPARED WITH SUNSPOT ACTIVITY, 1936–1940. FULL LINE CURVE REPRESENTS SUNSPOT NUMBERS OVER ENTIRE DISK OF THE SUN; DOTTED CURVE REPRESENTS VARIATION IN AREAS OF SUNSPOTS IN ZONES OF SOLAR LATITUDE 0° TO ±15° EITHER SIDE OF THE SUN'S EQUATOR. LOWEST CURVE REPRESENTS VARIATION IN RADIO FIELD STRENGTHS CORRECTED FOR SEASONAL AND DIURNAL VARIATIONS DUE TO ANGLE OF THE SUN BELOW THE HORIZON. THE FACT THAT THE LOWEST CURVE PARALLELS CLOSELY SUNSPOT ACTIVITY IN THE 0° TO ±15° ZONES SUGGESTS EFFECT OF SOLAR DISTURBANCES IS GREATEST WHEN SPOTS ARE NEAR SOLAR EQUATOR.

Anticipating a new field of research, a Boston radio engineer, Mr. G. W. Pickard, and myself became interested in the making of quantitative measurements of radio reception during the sunspot maximum of 1928 in an endeavor to discover if such anticipated effects on radio communication could be measured. After a few years' observations, it appeared to be evident that when solar activity decreased, the field strength of a Chicago broadcasting station observed in Boston notably weakened, whereas as sunspots became less numerous there was a marked increase in the intensity of the radio waves from Chicago. A similar investigation carried on during the decline of sunspots from 1930 to 1932 between Chicago and the Perkins Observatory of Delaware, Ohio, yielded data to indicate that with a decrease of sunspots from a monthly average of 60 at the be-

ginning of 1930 to a monthly average of about 10 in 1932, radio reception increased six-fold in its intensity.

Continued observations of the Chicago-Boston field strengths in recent years have continued to substantiate the general effect earlier observed. While there may be a 600 per cent. change in the field strengths between a sunspot maximum and a sunspot minimum, this does not mean that the degree of ionization in the Kennelly-Heaviside layer has been altered by this amount. The field strength of a radio wave at a given distance for a given frequency depends upon the angle of reflection or refraction which in turn is dependent upon the degree of ionization. Field strength also depends upon the absorption of the waves, which is a function of the conductivity. Appleton has estimated from his observations that the ionization and the electrical conductivity of the E and F regions in passing from sunspot maximum to sunspot minimum have shown variations of 50 to 60 per cent. implying that the solar ionizing agent (ultraviolet light) responsible for the formation of these regions in the ionosphere varies from 120 to 150 per cent. during the sunspot cycle.

We thus see that radio becomes a sensitive and extremely useful tool in recording changes of degree of ionization of the upper atmosphere. When we observe radio field strengths at long distances we are in a way tracing an integrated effect throughout the whole transmission path for a given frequency.

Another way in which we gain important information as to the sun's effect upon the upper atmosphere is by making radio soundings from day to day. This method, which has been in use for some years at the National Bureau of Standards, at the Department of Terrestrial Magnetism of the Carnegie Institution in Washington and elsewhere, consists in sending up a radio pulse of known frequency and recording its return from the reflecting layer. The time elapsed while the wave was traveling this path to the ionosphere and back is measured with high precision on an oscillograph. Assuming that the radio wave travels with the velocity of light, one can calculate from the elapsed time the height to which the pulse ascended before it was turned back by the ionosphere.

Soundings made of the ionosphere reveal different conditions at various times, displaying marked changes in the ionic density that are dependent upon the hour of the day and the season of the year. Routine radio soundings include changing the frequency at which the radio pulse is emitted. If the frequency is sufficiently increased, the shorter and more penetrating waves may pass completely through the ionized layer and not return. When such a frequency is attained, it is known as the critical frequency.

The close relation between the observed critical frequencies and the rise and fall in solar activity marked by sunspot numbers has been so apparent during the last ten years that the National Bureau of Standards now undertakes to predict three months in advance the best usable frequencies for radio communication based upon the sunspot cycle.

During the last few years of sunspot activity, there have been occasions when remarkable fadeouts have occurred in radio communication. In several of these instances extraordinary explosions have occurred on the sun simultaneously with the interruption of all radio communication in general. It would appear that the intense ionizing radiation from the region of the sun where these eruptions occur reaches the earth with the velocity of light and of sufficient intensity to disturb immediately the ionized layer, confusing the reflection of radio waves, and thereby resulting in these fadeouts which sometimes last for an

hour or more. Records at magnetic observatories show that during such instances characteristics of the earth's magnetic field are likewise suddenly altered.

Could we visualize the ethereal substance of the ionosphere as we visualize the surface of the ocean, we should find times when terrific storms were raging in this ionosphere. Here ions and electrons are being hurled hither and yon as

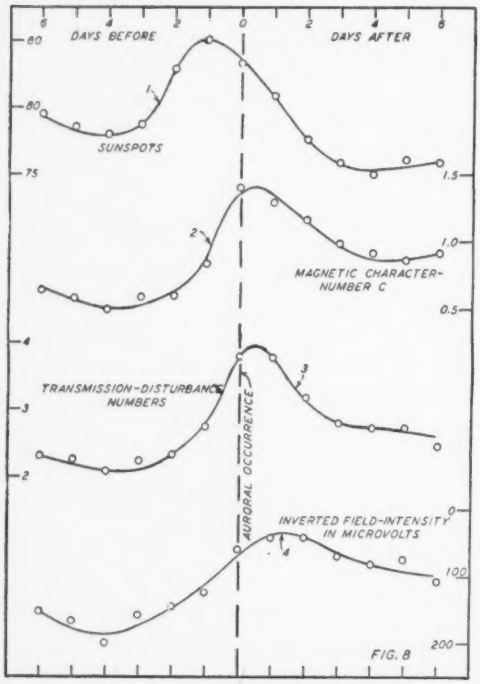

FIG. 8. CURVE SHOWING CORRESPONDENCE BETWEEN SUNSPOT ACTIVITY, TERRESTRIAL MAGNETIC CHANGES, DISTURBANCES IN THE F LAYER AND FIELD STRENGTHS IN THE BROADCAST BAND (E LAYER). ALL ARE PLOTTED WITH RESPECT TO DAYS BEFORE AND AFTER BRIGHT AURORAE.

though some great electrical wind played upon its surface, creating waves literally miles high. Frequently the turbulence attains such proportions that no reflecting surface for radio communication seems possible at all. When disturbances on the sun subside, the undulations in the ionosphere may quiet down and there is a return to more normal conditions for communication traffic through this ocean of the upper air.

While knowledge of the sun has helped us to understand the vagaries of radio, we are coming to see that radio is one of the most important tools for learning about what happens on the sun and how disturbances there affect the ions in this upper air. Perhaps some day, even though the sky is cloudy, we shall have a sufficient number of reports of radio conditions over the globe so that we can form a very good idea as to what is happening on the surface of the sun by the way in which world-wide radio communication behaves. Unlike the telescope, radio apparatus does not go out of commission when the sky is overcast, for electric waves, of course, pass through the clouds as easily as ordinary daylight comes through window glass.

Concerning the exact method or methods by means of which the sun produces all these electric disturbances of the upper air with the concomitant magnetic variations in the earth, we still lack a great deal of knowledge. The fact that the ultra-violet radiation from the sun is the major factor in producing this ionization appears a reasonable assumption. Whether or not in addition to the effect of the ultra-violet light, streams of charged particles also emanate from the sun in the regions of sunspots is perhaps still debatable, yet there is accumulating evidence that in addition to the wave radiation from the sun there is also a particle radiation that is primarily responsible for the violent magnetic disturbances such as accompanied the marked solar activity of Easter Week in 1940. The elaborate mathematical work of Dr. Störmer, in calculating the movements of hypothetical charged particles from the sun striking the upper atmosphere of the earth and thereby producing aurorae, would certainly seem to favor the idea that corpuscular radiation

of some sort is responsible for this phenomenon.

We have recently made a study of our last ten years of recordings of field strengths from WBBM Chicago as received in the vicinity of Boston for days immediately preceding and following conspicuous auroral displays. Comparisons have also been made of the index of sunspotedness for the same intervals. It was immediately apparent from our statistical analysis that on the average auroral displays followed by one day the highest value of sunspotedness, and that on the average one to two days after the auroral displays occurred, the weakest field strengths on the 770 kc. frequency were recorded. Since waves in the broadcast band are returned from the E layer of the ionosphere, it would appear that there is a definite lag of from 24 to 48 hours between the disturbances in the auroral zone and the greatest deterioration (ionization) in the E layer. Had we similar measurements of field strengths at higher frequencies representing waves returning from the F layer, we might expect a similar effect to occur at an interval intermittent between the time of maximum auroral display and the time of minimum field strengths from the E layer. Such field strength measurements are not available, but fortunately through the courtesy of the Bell Telephone Laboratories we had available a record of their transmission disturbances over oceanic paths. Taking the reciprocal of these transmission disturbance numbers, we have an index of transmission conditions comparable to the field strength measurements in the broadcast band. A plot of these transmission disturbances for reception from the F layer indicated a lag of roughly twelve hours after the auroral displays for the minimum transmission conditions. This provides perhaps as clear a confirmation as could have been anticipated for ionization disturbances occurring more promptly in the F layer than in the E layer. The curve of magnetic disturbances in the earth's field parallels very closely that of transmission disturbances in the F layer.

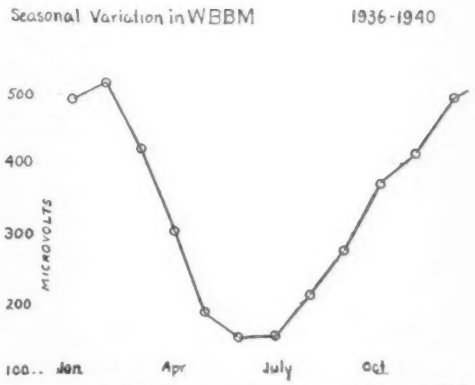

FIG. 9. SEASONAL TREND OF RADIO FIELD STRENGTHS (NIGHT) OF WBBM (770 KC.) AS RECEIVED AT BOSTON. VALUES HERE REPRESENTED ARE ST CORRECTED FOR TWILIGHT EFFECT; WHICH DEPENDS UPON ANGLE OF DEPRESSION OF THE SUN BELOW THE HORIZON DURING PERIODS OF OBSERVATION.

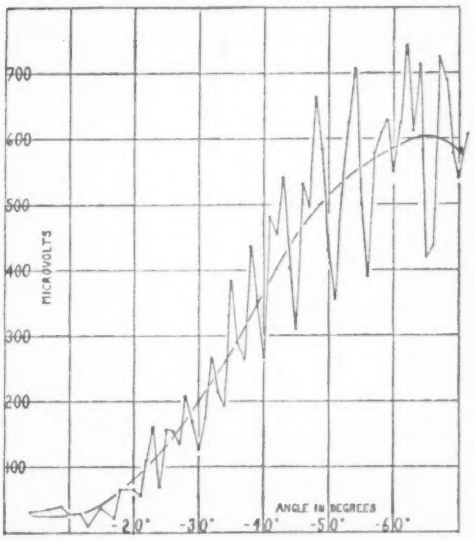

FIG. 10. CURVE SHOWING GAIN OF NIGHTLY FIELD STRENGTHS WITH THE INCREASING DEPRESSION OF THE SUN BELOW THE HORIZON BASED ON UPWARDS OF 8,000 HOURS OF OBSERVATION. THE SMOOTHED CURVE IS USED AS A CORRECTION CURVE FOR ELIMINATING SEASONAL TREND BEFORE COMPARING RADIO FIELD STRENGTHS WITH OTHER COSMIC PHENOMENA.

In utilizing field strength measurements for comparison with cosmic phenomena it has been necessary to apply corrections for the well-known diurnal and seasonal variations which depend upon the extent to which the ionosphere has been illuminated by sunlight during the preceding day. If such correction is not applied, we have of course a marked seasonal trend with a minimum of reception conditions in summer and a maximum in winter. The appropriate correction curve has been derived from over 8,000 half-hourly periods of observations, covering a range of $-5°$ to $-70°$ in the angular depression of the sun below the horizon during the observational periods utilized.

The possibility that an annual or seasonal change exists that is not allowed for by the changing declination of the sun led to the re-examination of all our data of the last few years with the result that a residual annual change apparently exists with a maximum in April and May and a minimum in September and October. The curve of this residual annual variation strikingly parallels the annual change in the distribution of ozone in northern latitudes as derived by Dobson. The parallelism of these two curves suggests that possibly the cause of the change in the ozone distribution is intimately associated with that of the changes in the ionosphere resulting in this variation in field strengths.

For the pursuit of these studies in cosmic terrestrial relationships a new laboratory for cosmic terrestrial research has been located in the outskirts of the town of Needham where conditions are favorable for radio propagation studies with a minimum of interference, and for observations of atmospheric electric phenomena away from the contamination due to manufacturing in a metropolitan area. The building provides approximately 2,500 square feet of floor space for offices and laboratories. The observational program includes the continuous recording of solar radiation, ultraviolet light, atmospheric potential gradi-

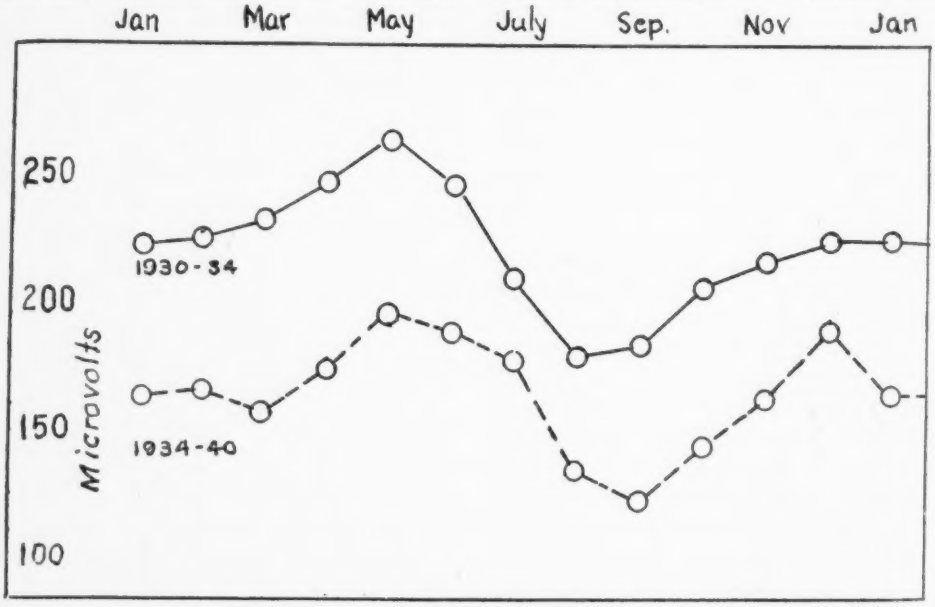

FIG. 11. RESIDUAL SEASONAL VARIATION IN FIELD STRENGTHS OF WBBM AFTER CORRECTIONS FOR TWILIGHT EFFECT OR ANGLE OF DEPRESSION OF THE SUN BELOW THE HORIZON. THE FORM OF THE CURVE IS SIMILAR TO THAT OF THE SEASONAL VARIATION OF OZONE CONTENT OF THE UPPER AIR.

ent, ionic content of the lower air and atmospheric electric discharges, as well as the continuation of the measurements of field intensities of radio waves both in the broadcast band and at high frequencies. The relationship of solar observations, ionization phenomena at high altitudes, and radio wave phenomena to the meteorology of the lower air affords possibilities for extensive investigations which may become of increasing importance.

Attempts to correlate weather changes with solar phenomena have thus far met with varying success. In spite of many conflicting results, it appears that in general the temperature of the world at large is somewhat higher at sunspot minima than at sunspot maxima. This seems at first paradoxical, since we might well expect that at sunspot maxima the sun would send us more heat and radiation than at sunspot minima. Many of Dr. Abbot's observations, especially during the earlier years, seem to corroborate this. Yet the surface temperature of the globe could be actually cooler in years when the earth is receiving more heat from the sun, for increased heat produces increased evaporation which in turn generally results in increased rainfall. Increased rainfall actually lowers the temperature of the earth's surface and again, by evaporation, continues to cool the air immediately above. Furthermore, with the warming of the earth, a vast convectional system of atmospheric currents results. As air warmed near the surface of the earth rises, cold air flows in from the polar regions with its chilling effects. It appears entirely possible that even with an increase in the heat received by the earth from the sun, so far as surface conditions are concerned, actually lower temperatures would occur at selected regions.

So far as changes in the sun's radiation affecting the general circulation of the atmosphere are concerned, it is to be expected that such changes would ultimately give rise to the formation of storms and the storm tracks resulting. One of the difficulties in establishing any intimate connection between weather and sunspots is that our observations of weather tend to be very local.

If progress is to be made, it will come through a consciousness of the distribution of weather as a whole over the entire globe. From a more accurate picture of world weather, indications for weather in a given locality at a given time may be more easily estimated.

Looking at the weather on a world-wide scale, Mr. Henry Helm Clayton, of Canton, Massachusetts, has found that pressures oscillate from one region to another in some way which appears to depend upon the intensity of solar activity. He finds there is an opposite trend over the continents and oceans in summer as compared with winter, and that the trend is different in the equatorial regions from that in the extratropical belts. In the equatorial regions temperatures are distinctly lower at sunspot maximum and higher at sunspot minimum. The same is true in the North and South Temperate Zones, but in the arid regions bordering the Tropics, the temperature actually averages a little higher around sunspot maximum than at sunspot minimum. From his studies he concludes that while the North Atlantic shows 10 to 20 per cent. more precipitation, the eastern half of the United States is in the region where rainfall is actually less during maximum activity on the sun. He concludes that our weather is the result of certain progressive wave-like movements of certain disturbed areas, originating in different parts of the world. With each cycle of change in solar activity, the centers of high barometric pressure move from high latitudes to low latitudes and back again. The amplitude of their oscillations and the speed with which these

waves progress appears to be inversely proportional to the length of the period of oscillation.

In years of unusually high sunspot maxima, as was the case in 1937, areas of high pressure appear to be pushed farther northward. The return of these highs to low latitudes with accompanying colder and clearer weather may, he believes, be so retarded under such instances as to invert the phase of a cycle that may have persisted for some time while the amplitudes of the oscillations were of less magnitude. Thus there will occur several years when the differences in barometric pressure between the equatorial region and North Temperate Zone become greater than normal, to be followed by several years when the pressure differences become less than normal. The shifting of these centers of action, Clayton believes, is definitely associated with sunspots.

Various attempts have been made to attribute climatic cycles to changes in solar activity. Perhaps the most outstanding scientific contribution in this direction has come from Professor A. E. Douglass, of the University of Arizona, who has spent a lifetime measuring variations in tree growth, especially in the forests of the Southwest and in California. Douglass noted that sequences in periods of rapid growth of trees, as measured by the widths of their rings, follow very closely the sequences in the sunspot cycle. Since variations in tree growth suggest variations in precipitation, he has accumulated a vast amount of evidence for alternations of wet and dry periods variable with the sunspot cycle, carrying records backward for some 3,000 years. His studies appear to indicate that at least for selected regions, trees have shown most growth when sunspots were most numerous. It does not appear improbable, however, that the growth of trees integrates all favorable conditions and that temperature, the quality of sunlight, and the amount of ultra-violet radiation all enter into the growth rate of trees as well as does rainfall.

Sunspot periods have also been traced with minor discrepancies in the flow of rivers and the level of lakes, some regions responding much more clearly than others to the sunspot cycle.

Altogether we see there are many indications that the earth responds to the changing state of the sun over an interval of a little over 11 years and often by double this period or approximately 23 years. Whether all the effects produced in the earth and its atmosphere that are noticed at sunspot maxima are the result of the sunspots themselves or whether the state of the sun and its whole surroundings are so activated as to change materially the cosmic environment of the earth is a question still unanswered.

In summary, we have reviewed a few of the important ways in which the sun and the atmosphere are closely associated. The solar cycle marked by the coming and going of sunspots appears definitely to be reflected in geomagnetic phenomena of the earth, in the ionization of the upper atmosphere affecting all radio communication, in climatic cycles of the past and in a somewhat complex manner with weather variations to-day. Perhaps some day terrestrial effects yet to be discovered may in turn become predictable through cycles that follow law and order. Difficult as the pursuit of such investigations may be, results already attained are a stimulus to sustained effort, and we are becoming increasingly conscious withal of a more intimate relationship between the earth and its cosmic environment than could have been suspected a decade or two ago. In this cosmic environment we may be assured the sun will play a major role.

PASTEUR: A STUDY IN METHOD

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I

THE era in which Louis Pasteur made his great contributions has gone by. And when we read of the shambles of the war of 1870 and the mortality in the hospitals then, or meet the present-day conditions in cities of the East where the microscopic is not hunted down, we realize with something of a shock how much we owe to the man who inaugurated that era. I am interested in the question, How did he come to be the one from among the hundreds of students of science in his day to formulate and demonstrate the new theory out of which such successful revision of procedure has come? It is true that conditions were ripe for his discoveries and that we find suggestions for some of them in earlier work. Was it chance and the pressure of his intellectual environment that brought Pasteur to eminence, or is there something uniquely fitted to meet the opportunity in the interests, the capacities, the habits of Louis Pasteur himself?

For a study of this sort we could wish Pasteur were living among us and we might watch and listen to him at work, and that he would have the happy habit of talking aloud to himself. Even then there would be much left out that we need to know. As it is, I have worked with far less, though the biography Vallery-Radot compiled brings the reader unusually close to the living man through quotations from letters, lectures and note-books and the narration of incidents and researches arranged chronologically. From these I have made selections grouped to illustrate the comments that occurred to me during a repeated study of the book, believing this to be an acceptable first step toward the full answer of my question.

II

There is no evidence that Pasteur showed any especial ability as a boy or any spectacular ability as a student at the École Normale. Some teachers and one or two fellow students who knew him intimately predicted great things for him. But in his early school days he was noteworthy only as a skilful master of crayons for portraiture. And in the several examinations taken at the École and at the Sorbonne he rated well below the top, though at the aggregation competition he received the comment, "He will make an excellent professor." He set a high standard for himself, took an extra year of preparation for the École Normale when his mark at the entrance examination was a low passing, in order to be better prepared for the work there; and then and always he worked long hours, absorbed in the particular problem at hand.

Two anecdotes suggest that early in his career he made independent judgments. The first, that he took a little volume by a M. Droz on "The Art of Being Happy" to church to read, and commented in a letter to his father, "In spite of all that a thoughtless bigotry might say, I am conforming to the very highest religious ideas." The other is that he spent long periods of his free time manufacturing phosphorus from bones which he himself bought, after the professor at the École had excused the class from the task as being too tedious and had given them a book description of it instead.

Laboratories and experimentation in general were not rated very high then. Only meager arrangements and those often not very comfortable were made for the training of students or the research work of professors. Pasteur on his part was called "laboratory pillar" by his comrades because he devoted so much time to making experiments, though oftenest these were little help toward passing examinations ahead. He carried on this work, too, with such enthusiasm, intelligence and devotion that certain of his teachers became much interested in encouraging him to continue research after school work drew to an end.

III

In those days of training his interest seems to have lain in perfecting his own powers of observation as much as in extending the range of his knowledge of theory. Indeed, one reason he gave in 1884 for choosing his earliest significant research, the study of tartar crystals, which developed into his first great discovery nine years later, was that he would have at hand the work of an authority recently published by which to check his own findings. The check was in the end reversed, for Pasteur found little faces on the edges of some of the crystals which his eminent colleague had not noted, and which gave him the needed clue to an explanation of the variations of effect on polarized light among the different tartars. Here his attitude toward the authorities of his day and the observations he himself makes is epitomized. He respected the first, but ultimate authority rested always with his own experience; and in his observations he was able to see the unexpected almost as easily as that which he expected to find.

This ability to see freshly and so heed what others had overlooked is often a starting point for discoveries throughout his life. He distinguished small globules present in lactic fermentation not hitherto reported and easily confused with others better known, and using these as ferment was able to show that lactic fermentation is similar to that of yeast. Examining the field where sheep were inexplicably developing anthrax, he discovered the source of contagion through noting something obvious but ignored before, a variation in the color of the ground and a considerable collection of little earthworm mounds in that part of the field which on inquiry proved to be the spot where the carcasses of infected animals had been buried.

He had, too, a habit of very careful examination of everything at hand, carried to the point of some embarrassment for a hostess in his more mature years as he investigated the tiny specks of dust on a plate or glass and wiped them away.

When learned colleagues seemed obstinate in misinterpreting his reports, he fashioned huge wooden models of the crystals under discussion, discarding words for an object to be seen and handled. This at a time when models and diagrams were far less used than at present, so that Pasteur felt it necessary to defend his method of presentation, almost to apologize for it.

Such eagerness to observe persisted rather dramatically in his later years. In 1887 when the family were at Bordighera for his health they were roused one morning early by earthquake tremors. As they left, despite the broken ceilings shaken by constant tremors, Pasteur "observed the effect on glass windows with much interest."

IV

Quite as characteristic as this sensitiveness to what is going on before him was his whole-hearted devotion to the single focus of his energies, devotion to science. His father was a soldier of Napoleon and Louis Pasteur may have thought of himself, too, as a soldier, one

of a group fighting to master the secrets of nature for the sake of better control by mankind. Two sentences in a letter to his father written in 1860, when he was thirty-seven, give this ambition: "At these heights all sense of personality disappears, and there only remains that sense of dignity which is ever inspired by true love of science. God grant that by my persevering labours I may bring a little stone to the frail and ill-assured edifice of our knowledge of those mysteries of Life and Death where all our intellects have so lamentably failed." Though he was deeply moved when the results of his labors helped relieve distress, and even had a certain dramatic feeling for the form practical application might take—"It would be really beautiful to make that agent of disease and death become its own vaccine"—his dominating aim was not the application but the formulation of scientific laws.

It led him in his student days to attend lectures outside his immediate field of work which gave him as a result a background of definitely wider range than that of his colleagues; and the practical questions in insect and animal and in human physiology on which he worked in his later life further extended his field. The resulting body of theory was not a conglomerate of sciences to him, it was an integrated whole, *science*. For instance, he carried over his observations, gained in the work on crystals, of the different reactions to agents of putrefaction of laevo and of dextrotartaric acid into the study of ferments, and out of that study of ferments developed hypotheses about the nature of contagious diseases.

Pensions awarded for labors accomplished with the expectation that he would be free to rest he took to mean opportunity for more research. We find Mme. Pasteur writing to her daughter in 1881, when Pasteur was nearly sixty and far from well, about a proposed scientific project in South Africa: "Your father would like to take that long journey, passing on his way through Senegal to gather some good germs of pernicious fever; but I am trying to moderate his ardour. I consider that the study of hydrophobia should suffice him for the present."

Pasteur was far from being an austere intellectual. Scientific investigation was an exciting as well as an absorbing pursuit to him. Incidents in his earlier days show the enthusiasm with which he worked, such as his rushing out to embrace the curator walking along the hall as a dearest friend when the test experiment with the tartars was successful. Letters to his family are filled with descriptions of his work so clear that his father became the first of a long line of pupils to catch that enthusiasm and share that excitement over results. Toward the end of his life he writes, "If I have sometimes disturbed the calm of our Academies by somewhat violent discussions"—as indeed had been the case —"it was because I was passionately defending the truth."

His very strong affections pulled him with, rather than against, this scientific interest. Throughout his life he strove not for his own prestige but for the preeminence of the country he loved so dearly, sometimes chose a problem to work on because results might lead to higher national standing, and advocated rivalry of that sort as the best expression of nationalism. The force of incentive such patriotic motives gave may be guessed from the instance when the two devotions, to science and to country, came into conflict. During the days of civil war in France the University of Pisa offered him a laboratory and a generous salary, and he replied, "I should feel that I deserved a deserter's penalty if I sought away from my country in distress a material situation better than it can offer me." It was much the same

with his personal affections. By good fortune or good judgment Pasteur chose a wife who like his childhood family attempted only one restriction on his laboratory work, concern for his health; a concern that was justified, especially after the paralytic stroke that interrupted work for three months when he was at the high point of his achievements and still under fifty years of age. With that concern went a devoted and trusted cooperation not only on her part but on the part of the children as well. When it was necessary certain bunches of grapes be carried from Arbois to Paris carefully protected against any contact, his wife and daughter were the ones who in turns carried the bunches upright. For weeks after his mother's death he was unable to do any intellectual work; but later his very grief for the deaths in childhood of three of his five children found outlet in the laboratory where the studies on fermentation were suggesting a means of preventing such tragedy in other households.

Though his deep religious feelings offered no reinforcement, neither did they create any barrier to his studies. The problem of coordinating his Catholic creed with his scientific work he refused to recognize as a problem, and no outside authority pressed it. "There are two men in each one of us," he writes, "the scientist, he who starts with a clear field and desires to rise to the knowledge of Nature through observation, experimentation and reasoning, and the man of sentiment, the man of belief, who mourns his dead children, who cannot, alas, prove that he will see them again, but who believes that he will and lives in that hope. . . . The two domains are distinct, and woe unto him who tries to let them trespass on each other in the so imperfect state of human knowledge."

V

If you had asked Pasteur for an explanation of his success, he might have repeated a comment he once made: "Assiduous work, with no special gift but that of perseverance, joined to an attraction toward all that is great and good." I do not know for what French phrase the last stands. It may fit a reference to this devotion to science better than the translation does. Certain it is that mere quantity of work would not explain Pasteur's discoveries, and that he knew it, for "without theory, practice is but routine born of habit. Theory alone can bring forth and develop the spirit of invention." His notebooks show comment, interpretation, suggestion of correlation entered one day and oftenest marked "erroneous" a little later, and there are found very early intuitions of the far-reaching hypotheses he long afterwards established.

But no fairy tale of clever imagining was enough. The scheme must of a surety fit the reality. And to be sure his theories did fit he planned and carefully executed experiments such as allowed of definite and convincing interpretation. The experiment with hens and anthrax gives a simple but quite perfect example of the sort of demonstration he wished. The birds were thought to have a special immunity toward the disease because they did not contract it. But Pasteur evidently doubted that and asked himself what if any physiological variation from animals they might have, for he tested the effect of their high temperature upon their susceptibility by putting one in a bath and again trying inoculation. This time the hen was sick, though another hen, also kept in the bath but not inoculated, and a third, inoculated and left to run about, both were well; and removal from the water was furthermore found to effect a cure. Not a special immunity explained the situation, but the blood temperature. This interplay of experience, imagination and rigorous analysis Pasteur calls the ex-

perimental method, and he repeatedly holds it up as an ideal. "We have experiments to straighten and modify our ideas, and we constantly find that nature is other than we had imagined. They who are always guessing, how can they know?" "Never advance anything which can not be proved in a simple and decisive fashion," he preached over and over again; though, as he once warned a group of young students, "what I am now asking you . . . is what is most difficult to an inventor . . . to constrain yourself for days, weeks, years sometimes, to fight with yourself to try and ruin your own experiments and only to proclaim your discovery after having exhausted all contrary hypotheses."

He did not forget a dissenting observation or rest satisfied to label it "exception" even after he grew confident of the fundamental truth of a theory. Sometimes it was years before he could clear the matter up, as in the case of the wineflower, which for so long a time seemed under certain conditions to turn into a quite different germ no matter how careful the technique used. Finally, after months of work Pasteur was able to construct a complicated apparatus by which he succeeded better in keeping germs from falling into the liquid from the air during his experiment, and alcoholic fermentation occurred no more. He could at last show that the wineflower did not change to an alcoholic ferment, but that the germ of such ferment had been added from the air, and that the wineflower, like all other germs known to him, was specific. In making such experiments Pasteur carried the finesse of tests to a much greater development than it had been carried before. Precautions for asepsis with which even the layman is somewhat familiar to-day (little things such as the temperature to which a container must be heated, higher than that the contained liquid requires) he came to by a process of trial and error from his own need for explaining seeming failures and developing impeccable methods.

Even after he was ready to proclaim a discovery there were the objections of opponents to be met. It took only three years of work to convince Pasteur that no such phenomenon as spontaneous generation occurred, but objectors repeatedly announced results that seemed to refute him; and in 1875 he writes with reference to a set of experiments announced from England: "For nearly twenty years I have pursued, without finding it, a proof of life existing without an anterior and similar life. . . . Whenever I hear that this discovery has been made, I hasten to verify the assertions of my fortunate rival. It is true that I hasten toward him with some degree of mistrust, so many times have I experienced that in the difficult art of experimenting the very cleverest stagger at every step, and the interpretation of facts is no less perilous."

In the effort to satisfy first himself and then his colleagues he dwelt with these problems constantly, and speaks of "sleepless nights" spent working out a simple formulation or a crucial test. The energy time expended was very great indeed. It is no wonder he himself emphasizes "assiduous work" involved in that experimental method.

VI

If we press our point a little harder, insisting that what we wish to learn is how it happened new interpretations of facts or new methods for tests occurred to Pasteur, we may do well to look a little more closely at details of his work.

For one thing Pasteur had the practice of seeking comments as well as observations where many would have ignored them. "Nothing should be neglected," was his rule; "a remark from a rough laborer who does well what he has to do is infinitely precious." He began a new

problem, first by mastering what was written on the subject if it were a new field to him, but next by questioning the people who were in day-by-day touch with the source material, silkworms, sheep, beer, pigs. Their guesses might suggest to him some more sophisticated guess of possible lines for laboratory experiments.

For another, he did not let his own distrust of success interfere with any research. At times this meant that he made a discovery against his own surmises, as with the transformation of tartaric acid into racemic acid in 1853, when he wrote his father: "Here is at last that racemic acid (which I went to seek at Vienna) artificially obtained through tartaric acid. I long believed that impossible. This discovery will have incalculable consequences."

His very thoroughness, too, led sometimes to rewarding surprises such as he might not have thought to work for directly. For instance, during his attempts to become quite certain by watching its action under every condition that the wineflower mentioned earlier either did or did not turn into an alcoholic ferment, he came upon a phenomenon new and very important to him, the change of life of the little fungus when submerged. This led to the investigation of other fungi for a similar characteristic, and from those studies to the dictum, "fermentation is life without air."

Again, though theory of some sort was, so he held, always to be sought, facts held the ascendency of power over any specific theory. Even well-established ones were not inviolable in Pasteur's eyes, not "fixed ideas." He was not afraid to study the possibility of spontaneous generation, though revered teachers warned him against its "obscurity," or to break into the conferences of medical men with his heresy of specific germs for disease; and he was definitely impatient with those colleagues who held to the teachings of their youth when shown experiments that could be explained only by a revision of those theories. As a person Pasteur himself had a sturdy self-respect that gave him dignity in any company, and for him facts had a corresponding dignity as facts in the presence of any given theory, however authoritatively backed. Such absence of rigid presuppositions freed him to imagine, much as he was free to perceive, the new and unexpected.

VII

Yet he was not blown hither and thither by each new difficulty or new surmise. "It is possible, but we must look more deeply into the matter," is a characteristic response. And though with him all theories were open to challenge of new facts, some were much more firmly entrenched than others. When a brood of silk-worms hatched from should-be healthy seed turned sick and pined away quite as those infected with pebrine do, Pasteur did not throw over or even question the method of selecting seed which he had so thoroughly tested, but patiently studied the dead worms for signs of some other difficulty, till his faith in the method he had so carefully developed was vindicated by evidence of another disease, flachery, in the brood.

In a time when arguments from and by *a priori* theories were so general, this insistence on the significance of cool evidence in discussion must have been a great contribution to the development of the biological sciences, particularly the applied fields; though the fervor with which Pasteur pressed such need perhaps makes the term "cool" inappropriate. He recognized a place and a use for the unproved speculation also, however. It must not be proclaimed or affirmed, by which he means, I think, urged upon others; but it is a natural and unavoidable development of human response to experience and may serve as a search-

light in research. A letter to his opponent Pouchet gives one of these aspects: "I think you are wrong, not in believing in spontaneous generation (for it is difficult in such a case not to have a preconceived idea) but in affirming the existence of spontaneous generation." And an entry in his note-book made during the civil war of 1870 gives another. "I could write that letter to Bernard. I should say that being deprived of a laboratory by the state of France, I am going to give him the preconceived ideas that I shall try to experiment upon when better times come. There is no peril in expressing ideas *a priori* when they are taken as such and can be gradually modified, perhaps even completely transformed, according to the result of the observation of facts."

It was not the strength of one's own belief that marked this distinction between doctrines properly or improperly affirmed though; it was the absence or presence of convincing objective proof. "When we see beer and wine subjected to deep alteration because they have given refuge to microorganisms invisibly introduced and now swarming within them, it is impossible not to be pursued by the thought that similar facts may, *must,* take place in animals and in man. But if we are inclined to believe that it is so because we think it likely and possible, let us endeavor to remember before we affirm it that the greatest disorder of the mind is to allow the will to direct the belief."

VIII

What I have to say now in conclusion I offer as belonging to that class of beliefs which Pasteur considered personal, suggestive only, and waiting to be modified or confirmed by further research. First, as I see it, we should remember that much of the detail of method noted in the preceding paragraphs is worked into the current techniques of to-day and it is easy to underrate its significance in the work of Pasteur's time. The very fact of his early interest in laboratory work, his great thoroughness in the development of checks and tests and in trying out all contrary possibilities and so on, bespeaks a stronger inherent interest in him than it would in a present-day student, to whom such work is part of an accepted routine. It is that concern to get and keep in close first-hand touch with his subject-matter that is one of the most outstanding aspects of his life; and we must consider "subject-matter" to cover all experience. The purpose that was strong enough to make him see what others overlooked and to "fight with oneself" for complete evidence in chemistry, mineralogy, biology, served also to cut through personal rivalry and vanity, traditional teachings and individual preoccupation with scientific work to a very full awareness of what actually went on in his own life as well as before his eyes. It was very deep in him. All the words I have used, interest, concern, purpose, imply a consciousness on his part of the rôle he was playing, which is hardly true. This eagerness for and openness to actual experience was, it seems, as natural as breathing for him.

In some ways, Pasteur may have been particularly fitted to contribute to the science of his generation where microscopes could help him actually to see the objects he studied. It may be he would not have been so much at home where elaborate formulas and inferences to the submicroscopic were needed. It is certain, too, that the warmth of his nature found satisfaction in the humanitarian aspects of his results, and though he considered those secondary to his main work, the theoretical, the fuller satisfaction may have made possible his very complete absorption in his researches, without the friction of restraint, which study of a more abstract set of problems could not have done.

Yet on the other hand he was so flexi-

ble, so open-minded, so objective, apparently, toward the new and unexpected that we feel he would, given the evidence, have quickly adjusted himself to advancing theory in any age. Wonder, almost awe, he seems to have felt as his own work developed, but we get no note of resistance to an hypothesis because it was startlingly new. The resistance was developed in his eagerness to escape being duped, to reach a real, not an imagined, world.

From what we know of him through his note-books we have reason to believe ideas came to him thick and fast. The labor he speaks of has to do with modifying them and weeding them out. Pasteur was, it seems, as concerned to get order into his experiences as he was to be clear-eyed in meeting them. And this again was a concern so deep in his nature as to call for no conscious direction on his part. He sought theories that should not only adequately explain experiments, but be so adequate as to include finally even seeming exceptions and phenomena wide-removed. The world of fact, of experience, dominated his interests, but not as a passing show. He sought to find organization there, to give it shape. Certain of the quotations chosen show how deep was his desire for order, for careful distinctions and classifications, even in fields quite outside his technical research; and Vallery-Radot tells us he felt poignant and lasting regret for the interruption set to a thorough study he had planned into the importance of dissymmetry in the general structure of the universe. I have noted how discovery in one field was carried over as a basis for hypothesis in another.

The difference between Pasteur's method and that of others seems to be a matter of degree, longer hours perhaps, deeper concentration, more acute observation, less constraint of tradition on imagination, a more persistent drive to discover wide and wider relationships and a more rigid search for flaws and more thorough examination of possibilities. We come near repeating ourselves as we name over different aspects of scientific work. But there is one other characteristic which the biography makes vivid to me and which I gain from the life as a whole rather than from single quotations. Pasteur had himself well in hand. He could weigh evidence without letting his desires get into the balance; he could fight with theories without being personal toward the men. He had a kind of glorified self-consciousness and could keep the primary and the secondary in his life clear of each other, and as he worked was aware of the varying basis for actions and for beliefs. Here again he was carrying to a further state of development something true of all scientists to some degree; but there are times when a difference of that sort becomes a difference, too, in kind, as when water growing colder turns to ice.

THE SCIENTIST AND SOCIAL POLICY IN THE DEMOCRATIC STATE

II. SCIENTISTS HAVE RESPONSIBILITIES

By Dr. CHARLES E. KELLOGG

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THE majority of people in our culture, including many scientists, have seen no pressing need for national and international planning. Haven't things been going along, generally getting better, they say, without it? Certainly the highest civilization ever known, as measured in terms of the material living standards of the average family, has developed in America. Since human nature is the same,[1] they say, and since cultures must have "growing pains," a few depressions and wars are inevitable, but after each we have emerged stronger than ever. The other arguments are familiar and need not be repeated.

True, certain individuals had predicted a calamity if more positive actions were not taken to fit the various pieces of our civilization together, but their predictions failed—we haven't fallen apart—not yet. In England and America, at least, we have always been able to "muddle through" somehow—and, many say optimistically, we shall do so again without a lot of fuss over planning.

What has given rise to this optimistic faith in the future? Perhaps much of it grew out of Christianity: whether in this world or another, man could look forward to something better. In fact, the whole of western culture is permeated with this interest in the future. Perhaps this common faith in the future on the part of scientists, religionists, socialists and capitalists is of greater significance than their differences. During the eighteenth century, however, many people became very pessimistic about the future. Population in Europe was increasing more rapidly than the food supply, or so it seemed. Near the close of the century Malthus wrote his famous essay. But the two great movements which he did not foresee had already begun: the rise of science and the expansion of trade and colonization into new lands. Through the application of science in agriculture yields of food crops were greatly increased in Europe, and colonists from Europe brought millions of new acres into use.

To most people science reinforces their faith in the future. As technological developments began, there seemed to be no limit. Each day, almost, one might expect something new. Then, regardless of what Darwin or other biologists have said, the great mass of people think of biological evolution only in one direction —upward and better. This faith in the future and in progress reached enormous heights in America, especially among city people, but also among many farmers as well. On every side things were "bigger and better," and "booster" clubs cried "watch us grow."

At least superficially, it does seem that the individual of to-day (January, 1941) has more, sees more and endures less physical pain than his ancestors. It is not surprising that people have acquired a great faith in science and feel no need for broad planning when so much has been done without it. But a very special circumstance permitted these developments: the rise of science was accompanied by the discovery of vast new lands.

During the period of growing political

[1] If this were true we would still be in caves with clubs, all of us.

freedom, when science was revolutionizing everything, all the minutiae of our daily lives and many of our fundamental ideas as well, there was a great outlet for pressures within the culture when they developed. From the discovery of America until after 1890 there were millions of acres of fertile soil, and an abundance of other natural resources as well, to be had for the asking and taking. This free land in the Americas, in Africa, in Australia, and elsewhere, provided a place for the adventurous, the discontented, the unhappy, the frustrated and the misfits. People from Europe had a place to go—a good place where the land was productive. Of particular importance was the fact that much of this new soil was similar to, or not greatly unlike, their own. They could build new homes, without completely changing their old habits. Near the end of this period, as northern Europeans have pushed into the dry regions and the tropics, more fundamental changes have been required—adjustments that have yet to be worked out satisfactorily.

Such an escape for more than three centuries had an unusual influence on western European culture and upon the civilization developing in the new world itself. There was not only room for an expanding population but an escape for those with new or unconventional ideas. Many came to the New World or went West, to escape public criticism or even imprisonment. The old society was thus easily relieved of the responsibility of making adjustments for these people and the adventurous found a place where they might begin a new life. Everything cooperated during the eighteenth and nineteenth centuries to produce change and to spread the European stocks over contrasting landscapes where differences in ways of life were essential for existence. And all this could be done without any extensive provision for social planning because the new land was free.

Talk about a relief program! The world had never seen the like before nor will likely ever see it again. Had it not been for this possibility for expansion, certainly our civilization would have been entirely different. Provisions would need to have been made for those groups who escaped to the new lands. Great industrial centers could not have been built from raw materials grown on cheap land. "Muddling through," as a public policy, simply would not have worked and would have been thrown out long ago in favor of some kind of conscious planning.

The process came to an end in the twentieth century—with a bang in 1914—and we are late with planning. Since the advance guard of the expansion had been agriculture, farm people were hit first—but the shock soon spread to every one, inevitably. The industrial life of America and Western Europe had also been built upon an expanding economy. Now people are piling up where they are. The new farmer to-day starts on expensive land. Others producing raw materials are in essentially the same position. Methods of exploitation that do not provide for secure production—continued production in the future—lead to disaster for those who can not move on to free land. Thus suddenly the social group is forced to make adjustments within the present area, and do so while there is time.

Overlapping Patterns

The recent emphasis upon the synthesis of scientific facts and principles with human values in the social world has brought fundamental changes in the philosophy of science itself. The classical scientist gave great emphasis to order and system. Each field of knowledge must be minutely outlined; and the facts, as well as the principles drawn

from the facts, were carefully classified. Although one can not deny the need and utility of classifications, they may become—frequently have become—static, and inadequate for guiding the application of knowledge to broad problems.

The static concept of order and system held by the classical scientist is giving way, slowly, to a dynamic concept, in which the *relevancy* of fact is as important to truth as fact itself. To the question, "Is it so?" is added the further question, "So what?" A fact of vital importance in one time or place, in one set of relationships, may be relatively insignificant in another time or place. The significance of any of these relationships is not to be had by the simple addition of facts or principles from different systems of classification.

The properties of hydrogen and oxygen do not "add up" to those of water; this substance has properties that grow out of the relationships between the two elements. In other combinations, such as oxygen and calcium or hydrogen and chlorine, they act differently. Thousands of different compounds—solids and liquids, foods and poisons—are composed of the same elements, carbon, hydrogen and oxygen, but with different patterns of relationship. Even more obviously, the distinctive features of a painting depend upon the arrangement of the figures and pigments, upon the pattern. They can not be defined in terms of static physical and chemical classifications.

Let us carry the example forward into the field of geography. Separate classifications of rocks, soil texture, slope, soil depth and all the other characteristics of the soil do not "add up" to a soil classification. Soils—soil types—must be defined as particular combinations of characteristics, in which any one characteristic has a particular relevancy. In one combination, a difference in slope or acidity, may have great significance; in some other combination—some other soil type—it may have none. Then, given a proper soil classification useful and adequate within its scope, one can not get a land classification (using land in its broad cultural and physical sense) by adding to it classifications of present land-use, cover, water power sites, marketing facilities and the other features that are somewhere relevent to the use of the land for production and as living space. The distinctive features of landscapes arise from the relationships among these many individual characteristics. Their usefulness to people and their fitness for social groups depends also upon the relationships among the elements of this pattern and the cultural notions—changing ideas, traditions, laws and institutions—of the social group.

This dynamic concept of science in respect to a changing world leads one to the appreciation of a great many overlapping relationships. A new technique in production, for example, changes the relative advantages of different kinds of land, different trade routes and different skills. The new method may solve some old problems, but create new ones with which people have had little or no experience. The requirements or influences of the new methods may conflict with older views of taxation, organization and social responsibility. Thus, gradually, an old virtue may even become a new crime.

We may think, for example, of labor, of agriculture and of business, or of investors, managers and workers. We may think of the East, the West, the South and the Middle West. We may think of conservative people, those who are ultra-conservative, the liberals and the radicals. We may think of the automobile industry, the radio industry, and the transportation system. But the same person, the same skill, the same idea or the same place may fall in several such groupings. Many people are both work-

ers and investors; there are farmers in all sections. A person classified as a liberal or a radical from the standpoint of civil liberties may be a conservative on questions of federal control of business. Strong advocates of liberalism in government may support with equal vigor the bureaucratic, undemocratic management of trade unions, corporations or individual governmental agencies.

People, regions, machines and skills belong in many overlapping categories. They can not be put into any one system; and even if they could, they would need to be shifted to-morrow. Ultimate completeness of system and classification is impossible. The newer dynamic concept of science denies the possibility of complete systems and fundamental causes. Scientists know now that there are many laws and many causes.

Those kinds or stages of scientific activities in which emphasis is upon discovery and description have been and can be conducted fairly well within the framework of subject-matter disciplines, like botany, chemistry and economics. A great deal can be gained, however, through cooperation among investigators and through the broadening universe of individual scientists, particularly as attempts are made to solve practical problems or to discover principles necessary for their solution.

In the invention stage or kind of scientific effort, a great deal more emphasis may be laid upon an appreciation of the world outside the special science. Much that is invention hardly involves science at all; it is rather art. The distinctions between art, industrial art, applied science and fundamental science are all very broad, indefinite lines. But some kinds of invention at least require a very detailed knowledge of scientific principles and their relationships. Whether or not the term scientist should include the user of scientific principles in invention and planning as well as the fundamental searcher for new principles is unimportant. Some would call the others planners or technicians, and reserve scientists for those engaged in fundamental science. It seems more appropriate, however, to regard as a scientist one who uses the scientific method and scientific principles, whether to discover new principles in science, new things or to understand relationships.

The planning stage or kind of scientific activity requires the fitting together of principles from many disciplines. Not only is the relevancy of the scientific principles in respect to one another important, but also emphasis must be given to their relevancy in relation to principles of morals and justice and of social values. And this must be done with no lowering of scientific standards. Too many so-called planners avoid their problem by oversimplifying it. The oversimplification of a problem, that is, bringing the problem down to the level of the planner, of course leaves the real problem still unsolved. The great need to-day is for the organization of attacks on the broad problems of great social significance so that our best and most detailed scientific knowledge may be used and the principles of science properly applied in respect to other principles. This must be done without "vertical" oversimplification through overspecialization in terms of a single discipline on the one hand, and without "horizontal" oversimplification through careless, superficial generalization on the other. And done while there is still time.

Slogans

Perhaps as a heritage from classical science, many folk still look for some fundamental cause, some one cause with some one panacea. The panacea is set into a slogan that is simple and easy to remember and repeat, one intended to electrify all human minds, set them on a

single course and put the social organism in order.

The modern problem of the slogan is becoming enormous. The technique has been studied and developed by all sorts of persons and groups, including politicians, advertising "experts," social reformers of both the left and the right, civic boosters and even organizations for charity. Although the principle is dangerous, all slogans are not necessarily bad. And they can't be eliminated by pressing for a new slogan, "Down with slogans."

In times past they have been useful where a fundamentally worthy purpose could only be achieved through mass action. At first the slogan may be simply a catch phrase to attract attention or suggest an idea, then a rallying call for leading a mass of people toward some objective, perhaps good or perhaps bad, depending on one's point of view, and possibly later it may become a rigid, over-simplified doctrine or article of faith to which all other ideas must be subservient. In this last stage it may lead to an extreme over-simplification of a complicated problem, and to merciless exploitation through rejection of other ideas of importance to human welfare, even under a banner that sounds good and simple by itself.

One has only to recall the famous slogan of the French, "Liberty, Equality, and Fraternity." Enormous forces for liberalism and democracy were marshalled under it for over a hundred years. (Many undemocratic acts were also done under the same banner, especially in the early years.) Yet perhaps its mere repetition led to a sort of lazy confidence in some mysterious force within the slogan itself, regardless of what people did or thought. The basic trouble is that thinking is difficult and the slogan offers a substitute as well as a rallying cry. Any substitution for thinking, whether developed as a slogan or in some other way, spells doom for social organizations conceived on liberal and democratic lines, whether governments or other sorts of organization, say of farmers, of workers or of scientists within the state.

As long as the democratic state remains in fact a democracy, the slogans of one-idea enthusiasts and pressure groups come into open conflict and can be discussed and compromised. Yet this is not always easy, even in a democracy. Frequently groups outside the government, or even within the government itself, may work under a beautiful slogan, under a statement of principle with which nearly all agree, yet work quietly for some more immediate selfish purpose. Sooner or later the ruse fails, the public awakens to the real situation. In many such cases the public reaction goes too far and throws out the good in the idea along with the unworthy who worked under a false banner.

Many times have the people been fooled, for a time, by misguided enthusiasts or selfish exploiters working under a banner of "prosperity," "security," "conservation," "health," "education" or some other worthy objective. If some one objects to what is being done, he may be identified with reaction and greed or dismissed as a quibbler. (The modern meaningless word of condemnation is "unrealistic." To the person who uses this word, all ideas, other than his own, are "unrealistic." Then there is a whole series of other words, similarly undefined, to apply to one's opponent in ideas—Communist, Fascist, reactionary, Red, etc., etc.). Yet there have been many times when the sincere and informed supporter of a worthy cause must take a stand against certain groups parading under a slogan for the cause, that is, he must if he is loyal to his responsibilities in the democratic state. If scientists lose their courage to do this, they will fail their fellow citizens; and

in this modern world democracy will be doomed.

Above all must scientists be depended upon to warn against the chimerical panacea. The problems of agriculture, for example, can not be solved by driving along any one course summarized as "attainment of parity prices," "every farmer an owner" or "save the soil," along with "production for use," "national planning," "grass-roots administration," "the American market for the American producer" or any one of a dozen other slogans. Each slogan may have a large element of merit and each may indicate the direction of a partial solution to a pressing problem. They are good if they stimulate thought and awaken interest. They are bad if they discourage thought. Each one could become a vicious, exploitive idea if overdone in respect to other vital considerations. Scientists have responsibilities to explain the relationships and inadequacies of these slogans and keep them from creating more problems, and worse problems, than they solve.

A close relative of the over-simplified slogan, so characteristic of our age, is the either-or complex. The world may have a few blacks and whites, but most of it is made up of grays. Central planning isn't completely right or wrong; nor is the idea entirely new or old. The government doesn't need to choose between no credit to farmers or householders and unlimited credit. One can not say that a certain type of soil or land is definitely productive or unproductive, in the abstract. Only in reference to particular sets of relationships can a degree of productivity be suggested. Some acts may be always wrong and some may be always right, but most are right in some situations and wrong in others.[2] Yet all the time scientists are being asked, we are all being asked, to fill out forms with instructions "to check either one or the other."

Certainly scientists should be aware of the inadequacies of slogans, and should not be misled into "either-or" divisions such as, for example, the recurring question of whether the scientist should be "theoretically correct or practically sound," as if there were such a conflict. Those who are really scientists, those familiar with the use and application of the scientific method and trained in objective scientific criticism, must be depended on to object and to explain. They must enlarge their universe of examination and criticism, if they are true to their responsibilities as citizens as well as scientists. Courage will be required—courage to make mistakes and admit them. May they develop this courage and assume their share of responsibility while there is time.

Scientists as Men

It has already been assumed that scientists have responsibilities as citizens and that they are human beings much like other folk. Scientists are born, educated usually at public expense, fall in love, go to the movies, drive cars, pay taxes and do all the other things that other folk do. They have no special immunities during periods of social crises, as has been shown time and time again. After being congratulated and receiving the praise of a sympathetic society (along with a fair measure of self-congratulation) they were probably the most confused segment of the population when the bubble burst in 1929.

Many scientists have accepted an

[2] Not long ago I received a letter from a professor in a great university listing several practices of farm husbandry, including the construction of terraces, the use of fertilizers, the growing of legumes like the clovers, and several others, and he asked me to check which *one* he should recommend for soil conservation in the United States in a book he planned to write! Of course, each may be good in some places, when done properly with others, and each may be indifferent or perhaps even very harmful in other places.

amazing dualism. They live in two worlds; their work is one, and their ordinary life is another. It is truly remarkable how they separate this work-a-day world in which we all live from their scientific world. The separation even extends to their fundamental concepts of philosophy and logic. The critical faculty employed so carefully in the laboratory, in field work, or in the library may never once be applied to other judgments—even to modern radio and magazine advertising. Although advertisers of scientific apparatus in scientific periodicals are very cautious in their claims lest they irritate the scientists, the names of the same scientists are regarded as an excellent "sucker list" for all sorts of other things!

Does a scientist fundamentally change when he goes to the movies, or enters military service, or supervises the education of his children, or seeks a remedy for a head cold, or walks through a labor picket line, or considers the qualifications of men for public office, or realizes he is broke? Is the scientist, after all, a sort of robot whose training and thinking are confined entirely to one small portion of his nervous system that has no relation to the rest of it? Of course not, but sometimes it seems so.

Perhaps this lack of awareness is not unique among scientists. Yet we have a right to expect more from them. Not only is democracy essential to progress in science, to the discovery of new ideas, new principles and new patterns, but the scientific attitude is essential to democracy. Between anarchy on the one hand and strict authoritarianism on the other, between the irresponsible skeptic and the unreasoning dogmatist, is the place of democracy and scientific reasoning, based upon evidence and logic, supported by faith in people and the dignity of the individual. Without this attitude democracy is doomed, science is doomed. Applied science, scientific technique, may flourish for awhile under autocracy, but not for long. The well of ideas and principles developed through the use of the scientific method in research soon runs dry.

It would be difficult, if not impossible, to over-stress the importance of this mutual vitalization of science and democracy. As citizens of a democratic state scientists have many privileges, not the least of which is that freedom for work and expression essential to science. But these are not privileges to exploit their fellow citizens or allow others to do so unchallenged, through the use of scientific skills and jargon. People have developed a great faith in science—a faith so great that the modern scientist has a staggering responsibility, not as an autocrat, not as some kind of high priest, but as a man and a citizen with special functions, like others with special functions in the democratic state. Any scientist who accepts the privileges and shirks the responsibilities, especially any scientist who attempts to use the people's faith in science to mislead them through falsehoods for his own personal gain or aggrandizement, is a serious enemy of the democratic state. Many may do so unwittingly. They may not be unpatriotic according to conventional standards, are even willing to join the fighting services if necessary, but they are unaware of the implications of their activities as scientists in a world of men.

For another citizen to avoid his responsibilities may be bad also. A farmer may allow his soil to become depleted for future use, because he doesn't know what is happening, or perhaps he doesn't care. A factory owner may permit conditions that ruin the health and happiness of his employees because he doesn't know or care. But for scientists, who have had great educational advantages, largely at the expense of some one else,

who have had the great privileges of learning the methods of science in a democratic state, to do likewise is many times worse. And they need to learn their responsibilities and accept them, not simply as an idealistic gesture in a sinful world, but as a vital matter of preservation for themselves and their children.

Our educational system in science, during and after college, may be partly to blame. We teach young scientists to become members of a group—a clique. We have societies for chemists, for geologists, for botanists, for economists, for anthropologists—indeed for about every conceivable breakdown of human knowledge. They may be good if not carried too far—but it appears that we have carried them much too far, in college among both faculty and students, and after college. Too much introspection is not good for either individuals or for specialized groups. They tend to become pressure groups for this or that, and especially for their self-interests and self-glorification. This kind of thing leads our young scientists away from other branches of knowledge, away from other values, away from people and away from democracy.

The scientific method needs to be taught and used as an everyday tool of living men, not simply as a special instrument for the laboratory to be locked in its case while the scientist is away from it. Few of our schools and colleges have even begun to realize the great educational value, as contrasted to the purely technical value, of the scientific method. The scientific method isn't just measuring and sorting and observing under controlled condition; it is also evaluating the evidence, arriving at tentative conclusions, criticizing these and other conclusions, and gradually improving our knowledge, gradually gaining a step toward truth.

These same processes of thought are essential to democracy. Ideas, prejudices and relationships must be studied objectively, evaluated, reshaped and fitted together so the ends of democracy may be realized and its processes kept vitalized and meaningful to the individuals who are counted upon to support it. These processes are controlled and operated by the citizens, by men. Among these scientists, as men, have great responsibilities and much work needs to be done now, while there is time.

THE RELIGIOUS FORCE OF UNIFIED SCIENCE

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If you should ask a member of a truly primitive people to explain his religion, and he could be made to understand your question, he would find it absurd. He would find it so for the same reason that we would find the following request absurd: "Define the universe and give an example."

Concrete instances of the world views of primitive peoples are furnished us by my neighbors, Lloyd Warner[1] and Radcliffe-Brown,[2] of the University of Chicago. They have lived on a close, friendly basis with the Murngin and Arunta, naked black peoples dwelling in the isolated wildernesses of Australia.

The life of an Arunta or a Murngin man is, in his own view, an exact cycle: The first life crisis occurs when his spirit, through a mystic experience of his mother or father—not a physical act—leaves the totemic well—an actual, visible spot in their country—and enters the womb of the mother. By circumcision around the age of seven he passes from the social status of children and women to that of men. When at around the age of eighteen he achieves parenthood and is shown his totems for the first time, he goes to another, higher status; and to a still higher when, at about thirty-five, he sees the high totems. At death he passes through an elaborate mortuary rite, returns to his totemic well. Some day the Arunta man will, he believes, come forth from his totemic well and be born again, as he has been many times before. He will be one of his own tribesmen, possibly his own grandson or grandnephew, and will have the same totem that he has always had, and keeps on having even in the periods when he is being dead. And so on forever and ever.

As far as an Arunta or a Murngin can see, no one, and especially no people, can possibly leave their country with its indispensable totemic wells. Obviously such a thing could not be, for how could he or any one else be born? How could there be any people? And how could there be animals and plants either if people did not perform rituals at their totemic places? For an Arunta the idea of life going on without the life cycle around the totemic places is as absurd as would be for us the idea of life going on without the earth's cycles around its axis and the sun. The Murngin's and Arunta's idea of the human organism, of animals and plants, of terrestrial regions and celestial bodies is integrated with the idea of their own societies. Their every act is moulded by this idea. I should say that their world-views are far more internally integrated and far more integrated with their and their people's thoughts and acts than is the world-view of most of the people you and I know personally. Similar observations on many primitive peoples besides the Arunta and Murngins have led to the early, only partially valid anthropological law that a primitive society is a sacred society.[3]

Continued observations and analysis, however, seem to show that it is not the

[1] W. Lloyd Warner, "A Black Civilization." New York: Harper Brothers, 1937.

[2] A. R. Radcliffe-Brown (formerly of the University of Chicago), "The Social Organization of Australian Tribes." London: Macmillan Company, 1927. Baldwin Spencer and F. J. Gillen, "The Arunta." London: Macmillan Company, 1927.

[3] Emile Durkheim, "Les formes elementaires de la vie religieuse." Paris: F. Alcon, 1912.

primitiveness of a world-view *per se*,[4] but its integration—a condition usually, though not exclusively, associated with primitiveness—which is constantly associated with religiousness,[5] with serene confidence in the world and the future, with mental security and peace, with uncompromisingly social behavior. The integration of physical, mental and social states, reified in daily action and symbolic rites, results in configurations whose force, transcending and subjugating all other human configurations, I call "religious force."

To-day this religious configuration is to be found in a few really primitive peoples, such as the Murngin and, among others, in some Catholics, some fundamentalist Protestants, and in some of Nazi youth[6] and most of Soviet youth. These men's whole personalities are integrated through uncompromising, brave, self-sacrificing action. The super-organisms[7] which these people collectively comprise are integrated by universally held goals and ideals, not sterilely believed, but effectively expressed in mass demonstrations, rituals, and labors.

Even with inferior resources and techniques religious super-organisms have in the past and do to-day dominate non-religious ones. Clearly, then, when I speak of religious force I do speak objectively of a natural force that can be observed and felt in oneself and in others, in individuals and in super-organisms.

This being the central point of my presentation, let me repeat that peoples who act in accordance with integrated world-views have the following vital characteristics in common: they have deep faith and strong confidence in their world and their future, and their respective communities exhibit extraordinary unity, direction, and power. Since all the above-mentioned peoples exhibit these important characteristics, and since no people whose world-views are not integrated exhibit them, I call not only some, but all, of them *religious* views; and the force not only of some, but of all, *religious* force.

II

All words, and among them "religion" and "science," are materials with which we think. If we are to build an efficient world-view these unit words must correspond to important unit actualities.[8] For us, important actualities are mental peace and united, powerful, efficient action. For the sake of effective thought, therefore, the word "religion" should apply to integrated, universal views, whatever their logical categories and not, as at present, be artificially restricted to views which include man-like, anthropomorphic gods.[9]

The notion of two contrasting entities, science *and* religion, is harmful to modern civilization: It leads to fruitless preoccupation with pseudo-problems such as the lengthy discussions, in churches and philosophy classrooms, of the supposed conflict or harmony between science and religion.[10]

It is harmful, further, because it constitutes an impassable barrier—for the period of its duration—between deeply emotional, socially useful world-views of

[4] Franz Boas, "The Mind of Primitive Man." New York: Macmillan Company, 1938.

[5] Ruth Benedict, "Patterns of Culture," pp. 21–23. Boston: Houghton Mifflin Company, 1934.

[6] W. Hauer, K. Heim, K. Adam, "Germany's New Religion." New York: Abingdon Press, 1937.

[7] Alfred E. Emerson, "Social Coordination and the Superorganism." *The American Midland Naturalist*, Notre Dame, Ind.: The University Press, 1939.

[8] Edward F. Haskell, "Mathematical Systematization of 'Environment' 'Organism,' ad 'Habitat,'" *Ecology*, January, 1940.

[9] Gerald Heard, "The Social Substance of Religion—an Essay on the Evolution of Religion." New York: Harcourt, Brace and Company, 1931.

[10] John Dewey, "Unity of Science as a Social Problem," Encyclopedia of Unified Science, Vol. I, No. 1. Chicago: University of Chicago Press, 1938.

the little schooled and the highly schooled populations; it hinders transition between their respective medieval and scientific languages and world-views. This conflict can be resolved to a considerable extent by appropriate translations and definitions of terms such as, for instance, the above definition of "religion." Discussion of this sort of translation is fruitful, for it can lead to mutual understanding and social harmony, to a sacred society. However, it can occur only when and where the idea of the essential differentness of science and religion is discarded.

And finally, as long as scientific theories are couched in logical categories denoting operationally inconstant unit phenomena, such as "science" as *contrasted* with "religion," unification of scientific theory itself is impossible. Only when these categories are redefined so as to correspond to operationally constant unit phenomena, such as the syndrome which I have defined as "religion," can scientific theory become unified, and science become religious even for scientists. If scientists themselves are hindered from unifying their world-view—if the salt hath lost its savor, to translate the notion into medieval terms—how can the people as a whole achieve it?

I cannot speak for others. But for me there are no such contrasting entities as science *and* religion. And there need be neither conflict nor harmony between them; for they can be one.

It is easier to correct the current meaning of the word "religion" when it is realized that this meaning is due to an historic accident rather than to efficient word-formulation.

In the early Middle Ages, Europe's world-view was nearly as integrated as the views of the Murngins and Aruntas. It did not include a totem-well theory, but it did include the notion of a stationary, square, flat earth, held up by angels, with the heavenly bodies revolving around it. Step by step scientists suggested that the earth is spherical and rotates about the sun. In so doing they broke the unity and universality of the medieval world-view. Because of this they were regarded as heretical, as unreligious, which at that time they unquestionably were.

But, as the centuries passed, scientists suggested that the earth with its living things was not created in six days, as their contemporaries thought, but evolved more gradually; they produced the skeletons of beings which resemble apes more than their contemporaries had believed the earliest humans to have done. They suggested that blood circulates instead of standing still, as their contemporaries believed; that plagues are caused by the growth of bacterial populations rather than blows of Gabriel's sword, as they were popularly held to be. And so on, down the line. In a word, the scientists' view became ever more integrated and universal, and thus religious, while the medieval world-view became ever more disintegrated. It is through this historic accident that we have to-day been maneuvered into calling this medieval view "religious" when it has lost much of its religious force[11] and calling the scientific view "unreligious" when it is in many cases already deeply religious,[12] and is daily becoming more highly integrated.

To say, however, that unified science exists in the world of to-day, when the symptoms of mental *dis*organization—armed conflict, suicide, and insanity in their myriad forms[13]—are rampant, would be to contradict the notion that

[11] E. L. Thorndike, "Your City." New York: Harcourt, Brace and Company, 1939.

[12] Eve Curie, "Madame Curie." New York: Doubleday, Doran, 1937.

[13] Karl A. Menninger, "Man Against Himself." New York: Harcourt, Brace and Company, 1938.

a unified world-view and moral, harmonious action constitute a unity. Instead of saying that science to-day is unified I would say that scientists are still divided into specialized discipline-groups, each with its own language, literature, and institutional administration; that each group of specialists—partly through necessity and partly through historic accident—is to-day ignorant of many crucial inter-relationships of the several scientific disciplines; that these groups duplicate each other's results in some places and leave gaps between them in other places; that each group is logocentric, over-emphasizing the part played in the universe by the phenomena it studies and under-emphasizing the part played by other phenomena; that consequently most of these people are scientists in their offices and laboratories, and non-scientists outside. Even *during* their working hours, as William James pointed out, most scientists are so concerned with isolated fragments of existence that one may well say that on the whole the influence of science goes against the notion that religion—a unified world-view—should be recognized at all.[14] And this view has spread among the public until, to quote Robert Hutchins, "The most characteristic feature of the modern world is bewilderment. Any one who says he knows anything . . . [about the whole] is at once suspected of affectation or falsehood. We do not know where we are going or why . . ."[15] That is to say, most people do not even realize that the world's present retrogression is in large measure the direct result of the non-integration of views and of actions, and that it can be halted and turned into progression *only* by the development of a world-view which is scientific, which is integrated and universal, which is vigorously expressed in action; which, in a word, is religious.

While science is not yet clearly unified, powerful unification movements are well under way. The physical sciences have undergone and are undergoing unification as a result of Einstein's theory; that is to say, as a result of the redefinition of logical categories in such ways that they become operationally constant. The technique of redefining terms is now being extended to the biological and social sciences, the methods for doing this being systematically developed by men working with what is called the general theory of signs.[16] (As you can see, this technique is being applied, in this very article, to the terms "religion" and "science.") Symposia and round-table discussions are being held at the congresses of the American Association for the Advancement of Science by scientific organizations which did not meet together a few years ago. Their discourses are being published both in journals devoted to science as a whole and in journals which would formerly have barred them as alien subject-matter.[17]

[14] William James, "The Varieties of Religious Experience." New York: Longmans, Green and Company, 1925.

[15] Robert Maynard Hutchins, "The Issues in the Higher Learning," *International Journal of Ethics*, January, 1934.

[16] Charles W. Morris, "Foundations of the Theory of Signs," *Encyclopedia of Unified Science*, Vol. I, No. 2. Chicago: University of Chicago Press, 1938.

[17] To-day the Western Hemisphere's foremost scientific organization devoted specifically to the synthesis of scientific theory is the Congress for the Unification of Science and its *Journal of Unified Science* (formerly *Erkenntnis*), and the International Encyclopedia of Unified Science edited by some of its members. To the best of my knowledge, the University of Chicago is the first university to take organizational steps for the specific purpose of unifying scientific theory: the Interdivisional Committee on Unified Science, with Alfred E. Emerson (zoology) as chairman, Charles W. Morris (philosophy) and W. Lloyd Warner (anthropology) as members, to supervise and guide my efforts in this direction. The university has further facilitated these efforts with the grant of a special non-divisional fellowship. I should like to express my indebtedness for the help given me by this committee, and also by W. C. Allee and Robert Redfield in the formulation of this article.

The religious force of unified science is already manifesting itself visibly: the most fruitful methods for handling the terribly destructive force of the conflict between employers and employees have been discussed by my scientist neighbors here in Chicago, and their associates elsewhere.[18] Such creation of harmony is a religious activity achieved through the practical application of a synthesis of the theories of many diverse scientific disciplines.

Integrated scientific studies have religious force because the social effect of any kind of action becomes apparent when—and only when—situations are viewed as wholes. Once effects are thus seen, they are inevitably *evaluated.* That is to say, processes are seen to be integrating or disintegrating; to be helpful or harmful to society; in a word, to be good or bad. Unified science is, like all religions, inescapably and directly connected with values, ethics and morals.[19] And values are connected with action. The religious force of unified science (unlike that of most other world-views) is manifested in integrated knowledge, mutually comprehensible speech, and uncompromisingly social action.

As science becomes unified mankind becomes powerful. Its power makes the world safer. The power of men gives rise to faith in the goodness of the universe and hope for the future of mankind. (This follows consistently because the world is "promising" and "good" to the degree to which we do make it, and expect to make it, meet our needs.) In short, unified science gives the power of knowledge, of faith, and of efficient action to the individual and to society. This power is the religious force of unified science.

There are men who to-day see science as their way of life; as the guide of their family intimacy, play and work; as the moulder of their private and public policy. These men, of whom I strive to be one, regard the development of unified science, and its linkage with its allied expressions, art and industry, as the development of the highest good: We view it as the growth of the quality which gives men dominance over inanimate nature, over the fate of other organisms, and over men's own destinies.

We view the individual and public policies which are conceived and carried out with humble and uncompromising realism, which are scientifically conceived and executed, as manifesting something of the divine. (And let every man define the term if or as he is willing and able to define it.)

III

Man-made organizations, such as machine factories, plant fields, and animal herds, do not consistently maintain a higher level of integration than the integration of the ideas they reify.[20] This was shown concretely during the early years of Soviet construction, when quantities of complex machines, bought

[18] Fritz J. Roethlisberger and William J. Dickson, "Management and the Worker" (Cambridge: Harvard University Press, 1939); Elton Mayo, "The Human Problems of an Industrial Civilization." New York: Macmillan Company, 1933.

[19] In the terms of the general theory of signs (footnote 16) unified science would be termed something like this: "An increased integration of pragmatic, semantic, and syntactic representations." In the terms of physiological theory: "Integration of the activity of the lower nerve centers with that of Pavlov's 'cortical analysers' and that of the speech and silent areas of the cortex." In the terms of Medieval Europe: "Closer communion of body, mind, and spirit." Such integration always and inevitably involves integration of man with his habitat. And this occurs in large part through scientifically directed action.

[20] Edward F. Haskell, "Ecological Formulas for Tools, Pictures, and Formulas," a paper prepared for the American Anthropological Association at its meeting in the American Association for the Advancement of Science, Philadelphia, December, 1940.

at great sacrifice, were ruined by non-complex peasants and workers who were striving desperately to preserve them. It is illustrated once more a few years later, now, when these people's ideas have become more highly integrated: unintentional deterioration has not only decreased, but machines are being repaired and produced in large quantities.

Our American super-organism was not planned by men but developed crescively. It just grew, like Topsy. Its rate of growth is the reverse of any mammal's rate of growth, and greater than the rate of earlier human societies: It took small-brained, thick-skulled Paleolithic men nearly a million years to develop percussion-flaked (Pre-Chellean) tools into pressure-flaked, hafted (Aurignacian) flint tools.[21] It took us, larger brained mortals, only about 17,000 more years to develop the poorest steam-driven tools, and a mere 250 years more to develop tools (pursuit planes) that carry us up to 650 miles an hour. (And, according to the aeroplane designer, Igor Sikorsky, barring some catastrophic event, both the stratosphere liner, traveling at several thousand miles an hour, and the space rocket should be perfected within the next hundred years.[22] These speeds are cited as "indicators" of a general condition:[23] the condition of a highly accelerated evolution of superorganismic structures and processes *in general.*

John Dewey has pointed out that there are anti-scientific forces in and outside our universities which actively oppose the unification of science (see footnote 10). In so far as these forces guide civilization it must and is breaking down with the full force of its acceleration until its structure reaches and, by its own momentum, passes below the degree of integration of their mental structure. The torpedoes, bombs, shells and gases being produced in the world's mines and factories,[24] the direct mass slaughter and the indirect slaughter through the epidemics and famines (present and soon to come)[25] seem to me to be in large measure the result of our maintaining today unintegrated views appropriate to earlier, less integrated social conditions; views, therefore, which produce actions highly disorganizing to modern society. In short, this slaughter is an effect of cultural lag and, unless actively guided by men with integrated minds, may convert lag into disastrous wholesale retrogression.

On the other hand, in so far as the men who achieve unified science guide civilization, it must build up until its structure approaches the degree of accuracy and integration of their mental structure. Growing techniques of industrial and scientific cooperation, consequent improvement of nutrition and health, general decrease of social and internal conflict and its symptoms, suicide and insanity, together constitute social integration. They constitute the progression which, as stated, should sooner or later result from generally creating and acting upon a unified scientific world-view. The struggle for such a view, it is true, is temporarily painful because it robs men of peace and force until integration is nearly achieved. But those who approach it closely enough to be assured that it can be achieved do feel and

[21] N. C. Nelson, "Prehistoric Archaeology," Chapter V in "General Anthropology," edited by Franz Boas. Boston: D. C. Heath and Company, 1938.

[22] Igor Sikorsky, "The Story of the Winged-S." New York: Dodd Mead Company, 1938.

[23] J. E. Weaver and F. E. Clements, "Plant Ecology." New York: McGraw, Hill and Company, 1927.

[24] League of Nations, "Armaments Year Book," Geneva, 1938; Jane's "Fighting Ships," London: Sampson, Law, Marston and Company, 1939. Both these books understate actuality and are vastly out of date.

[25] "The Lord's Battalions" (listed in the table of contents as The Friends Service Committee). New York: *Fortune,* December 1940.

manifest its tremendous religious force. They feel that progress depends upon our *advance* to religion; to unified science.

From these considerations it seems to follow that to-day the crucial point of human advance is the necessarily cooperative activity of integrating the theory and practice of the several sciences, and teaching the resultant unified world-view to those personally concerned with organizing progress; which is almost everybody.

Concretely, this implies—as a start—the energetic execution of some such program as this:

I. Intensive study and development of the techniques necessary for the efficient handling of logical categories and their notation, such as the theory of signs and mathematical logic.[26] Institutionally organized, *integrated* polymathic courses of study (footnote 17) furnishing the data to which these techniques are to be applied.

[26] W. V. Quince, "Mathematical Logic." New York: W. W. Norton and Company, 1940.

II. Development of our sporadic symposia into a permanent, interconnected organization led by an appropriate, trained polymathist.[27]

III. Conscious, persistent integration of these organizations with popular churches, schools and clubs at strategic points.[28]

This program proposes a conscious intensification of strategic processes already present in our democratic way of life. If carried out it should integrate the united nations as well as the minds and activities of their individual citizens. For, as our minds become increasingly integrated, our organizations will integrate themselves in like manner.

The goal of this process is a modern sacred society: Its method is scientific; its extension, universal; its direction, progressive; and its force, religious.

[27] An example of such an organization would be the Speciation Committee headed by Alfred E. Emerson. *Science*, 1940.

[28] The present article is a concrete demonstration of the feasibility of such a proposal: It was originally presented (in a briefer form) before a Quaker meeting—a unit of the Religious Society of Friends—of which I am a member.

AMERICAN CHARACTER

BUT there is one factor that may be more important than all others—the American character. There have even been doubts about this. One can estimate the tone and temper of a people somewhat from its songs. In the early days of this Republic its citizens sang "Hail Columbia," "Adams and Liberty," "Columbia the Gem of the Ocean" and the like. These were martial airs, but apart from their ring of defiance there were notes of pride and confidence in the destiny of this nation, of individual energy and of individual dedication—all applied to the achievements of peace as well as to those of war. A few years since, our popular songs were known as "blues." They were songs of distress and despair, songs of resignation and self-pity. And this was in a country that, to outward appearance at least, had already realized far more than the high prophetic hopes of a hundred and fifty years ago. No one questions that the people of the United States are the best fed, the best clothed, the best housed people in the world.

We are not arraigning American civilization on the frail criteria of songs; we are not arraigning it at all. But there is abundant evidence that something has happened to blur our vision of the benefits that American life has given and is giving to every one of us, the grateful and sacrificial loyalty that naturally follows and the duty that membership in such a nation entails upon each citizen to carry on its best for the good of all posterities to follow. A close examination will make clear that the trouble was far more with the vision than with the facts. There are fashions in thought as there are fashions in art. It became fashionable to take a "blue" view of America.—*Address of Dixon Ryan Fox, President of Union College, at the Inauguration Ceremonies of President Robert L. Johnson, Temple University.*

THE AGE OF HOMO SAPIENS

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IT is customary to speak of the time since the beginning of the Ice Age, or the last million years, as the Age of Man, because its geological deposits are embellished with the stony fruits of human handiwork as well as with the fossilized fragments of man's own frame. But this is otherwise a loose term. What kind of a "man" is meant?

As an erect animal newly distinct from an ape, with a growing propensity to reinforce his hands with rocks and sticks, man is probably older than this, by far. De Terra, it is true, believes that the advent of the ice itself, shifting climatic zones southward in Asia and causing a dispersal of the once flourishing ape family into new and varying environments, was the indirect stimulus to the emergence of man from the anthropoids, so that this event, he thinks, must have happened within the Pleistocene period itself. But many students, Hooton being the most articulate, feel that man must have been evolving for several million years at the end of the preceding Tertiary era, using tools of stone which can not even be recognized to-day, before getting to the stage of physique and culture which we see in the earliest known remains. Man's age, in other words, is doubtless several times as great as the "Age of Man."

On the other hand, we ourselves, in our present form, constitute one particular and definite species of man, the species *Homo sapiens*, which must have arisen later on within this total limit of time. He is an advanced type and is distinct from various other known human[1] forms. However, almost all these forms seem to be well above, and therefore later than, the earliest imaginable stage of true humanity, and all may be thought of as lines, gradually separating, which descended from the original human stem. *Homo sapiens* appeared somewhere as such a line but how old he is, as a species, we do not know. Curiosity as to his age is not simply the mark of a fond antiquarianism, for information on the pace of recent human development would give us a better perspective for the possibilities of future change in mankind. How old, then, is *Homo sapiens?*

We really can not say, taking the remains alone. If we dutifully repeat only what paleontology has revealed so far, it would seem as though *Homo sapiens* were very recent. (Actually, we know somewhat more about the age of our nearest neighbor in time, the species of Neanderthal Man.) There is, however, some imperfect evidence that indicates *Homo sapiens* as being fairly ancient, and there are various abstract considerations and deductions which bear this belief out.

Put purely in terms of skeletal evidence, this is what we know. 1. There is archeological proof of human existence apparently throughout the Pleistocene, running back a million years, to use a figure, or 1,000 millenniums. 2. There are remains of the species *Homo sapiens*, and *Homo sapiens* only, going back some 30 millenniums (more or less, actual dates not being certain) to the Cro Magnons, who appeared at the beginning of the Upper Paleolithic, the last portion of the Old Stone Age. 3. In the previous 950 or more millenniums (the disproportionately long Lower Paleolithic, comprising 19/20 of the whole Pleistocene)

[1] "Human" in the anthropological sense refers to the whole hominid family, and not to our own species alone.

there were various types of fossil men, but no finds have been made which would prove, with the finality of a theorem in geometry, the presence of *Homo sapiens.* Thus there is a break, at the beginning of the Upper Paleolithic, with no indisputable men of our own species earlier, and no men of any other species after it. The situation is such that only the captious would deny that *Homo sapiens* existed before the Cro Magnons, who are his first clear manifestation; but on the other hand it is not such that any anthropologist can wring general agreement from his colleagues as to a particular time, whether relatively late or going back toward the beginning of the Ice Age, when *Homo sapiens* might be said first to have become a distinct species.

Through the long reaches of the Lower Paleolithic there is sprinkled a corporal's guard of human fossils. The Neanderthal species is well represented by finds, especially in the west, which can be referred to the last 100 millenniums or more of this time. Equally well known (for the cranium at least), thanks to recent discoveries, are the Java and Pekin types, obviously related to one another and probably dating from the lower middle part of the Pleistocene. Aside from these, the main species are largely single specimens or scraps: the Heidelberg (an early forerunner of the Neanderthals) and Piltdown men, and the undatable Africans—the Broken Hill skull of Rhodesia, and Africanthropus, from the Lake region. Of all these and certain others none is assigned to *Homo sapiens.* This gives a picture of several species of man, some of whom at least must have been contemporaneous, though differing considerably. The question is: Did *Homo sapiens* also overlap any of them in time, or did he, appearing late, arise from one of them, and if so, from which one?

The possible representatives of our own species during the Lower Paleolithic are not many. (There are reasons, however, for not expecting them to be. For example, *Homo sapiens* has a thin skull, which is less likely to survive in fossil form.) One is the Galley Hill skeleton of the Thames valley, whose physical type is fully *sapiens* but whose geological claims to antiquity are impaired by the confusion and carelessness which attended its discovery in 1888. There are a few other modern-looking skulls with similarly sullied credentials. Otherwise the skeletal evidence of early *Homo sapiens* rests on two finds. The first is the very important Swanscombe skull, also of the Thames valley, whose parts were found in an absolutely certain connection (a rare thing) with glacial deposits and archeological tools which are believed to belong to the second interglacial, in the first half of the Pleistocene. It is thus very ancient, but its establishment as an actual specimen of *Homo sapiens* has to rest on the crown and back of the head, all else being gone. This is not entirely satisfactory. Most are inclined to accept its validity, and to believe that it legitimizes Galley Hill at last, but some would regard it with acute suspicion, remembering that the back of the ape-jawed Piltdown skull would seem almost equally modern. The other main find comprises skeletons from two caves at Mount Carmel in Palestine, excavated ten years ago and dating apparently from the later part of the Lower Paleolithic. In the Tabun cave was found a Neanderthal-like woman with some *sapiens* characteristics, while the Skhul cave contained several skeletons of a practically *sapiens* type but with Neanderthal-like features. The interpretation of all this is likewise in doubt. The discoverers believe that they have found what is perhaps the actual moment of appearance of *Homo sapiens,* while others think the skeletons represent a mixture of the two species, in which case *Homo sapiens*

must already have been in existence, and probably for some time.

This is not much with which to reconstruct the trail of *Homo sapiens* into the past after the visible part of it disappears abruptly with the Cro Magnons, or at best becomes pocketed in the mysterious case of the Mount Carmel skeletons. Even if we provisionally accept the Swanscombe skull as a specimen of *Homo sapiens,* there remains a large gap in time between it and the Cro Magnons, bridged only by a moral certainty. Consequently there is a flourishing diversity of opinion in the whole matter—notice that even regarding the Mount Carmel skeletons alone there are currently two quite different explanations, logically leading to equally different conclusions as to the age of our species. In general there are two schools of thought. One holds that the development of *Homo sapiens* was independent of that of other species, all of them being considered as a constellation of different descendants of a common source placed well back in Tertiary time. At the other extreme are those who would graft him onto some one of the known non-*sapiens* forms of man, at some period well along in the Pleistocene.

Neanderthal Man supplies a case in point. Becoming extinct less than 50 millenniums ago, he seems to have ruled Europe for the preceding 100 millenniums at least. A few students think that during his career he gave rise to, or influenced, *Homo sapiens.* Others feel that this is not so; that his physical unlikeness, in his low, massive head and huge face, is too great, and that he had developed definite peculiarities of his own which are not to be found in modern man and which would therefore exclude him from our ancestry. In spite of all the racial variety of the latter, and a considerable variety in the Neanderthal species as well, there is no actual overlapping of the two stocks in physical form.

Now if there has not been any important connection between the two species in recent times, then it would appear that *Homo sapiens* existed somewhere outside of Europe, and that his line goes back, parallel to but not connected with that of the Neanderthals, for many thousand years. Does it go back to the Java and Pekin types, or is the same situation repeated here? Probably it is. The Swanscombe skull shows, if it shows nothing else, that a high, vaulted brain case of the *sapiens* type, whether actually parental to that of our species or not, had been evolved in the human family long before the known period of the Neanderthals, and almost certainly as early as, or earlier than, the backward Java-Pekin family. And the always-mysterious Piltdown skull, in spite of its extremely ape-like jaw, has a very human brain case which indicates the same thing.

It is possible to disregard the limitations of the fossil evidence and to take a fresh view of the problem by considering the living races of *Homo sapiens* as they now stand, and as they have probably been in the past. To-day two billion people are spread thickly upon the earth. They are divided somewhat unequally into the conventional White, Yellow and Black, with infinitely weaker representations of American Indians, Australian blackfellows, South African Bushmen, and so on. They constitute different races but all belong, from a zoological standpoint, to a single species. None of these races alone is the type of the species, which is made up of all of them together. In other words the most advanced is not necessarily the most typical. It would indeed be more proper to represent *Homo sapiens* as a whole by his most primitive manifestation, the native Australian, or by an imaginary form of this sort, which could have become the parent of all living races, as a sort of greatest common denominator.

The picture of the present suffers from

lack of depth, because our collections of skulls of various ethnic origins do not go back far enough to tell much of history on a grand scale, and the older remains give us only the barest of indications as to race. Nevertheless, it is clear that before we even begin to trace races back we must modify this picture because of violent changes which must have taken place in the very recent past, in the time since culture really began to develop.

A mere ten thousand years ago, toward the end of the Paleolithic, man knew only the art of hunting. Since then, with the onset of the Neolithic, he has progressed to agriculture, opening a vast food supply to himself; later on, in the Bronze Age and classical times, he has benefited by town life and artisanship, and still later, in the last few centuries, by the subjugation of natural forces to the purposes to transportation and manufacture. These things have occasioned an almost incredible increase in the population of the world. Throughout his previous existence, man could never rise in numbers above what the stable animal population in any region would feed. It can be estimated, from the little that is known about the recent rate of increase, and the population density of present-day hunting peoples, that there can have been only something like ten million beings in the then inhabited world, compared to the two billion of to-day. (For example, the New World, most of whose people were relatively advanced in culture, had a population of roughly eight million at the time of discovery.) Now in this tumultous upsurge of some two hundred fold, it is plain that those peoples who participated in the progress of culture would increase and monopolize the world, while those who remained hunters would continue to be few in numbers and sparse in distribution, or would even face extinction on encounter with a people more advanced.

Ten millenniums is a very short time, being only one hundredth of the "Age of Man," yet it has produced this revolution, this amazing upheaval in numbers and in attainments, which is in vivid contrast with the long previous span of man's existence during which culture had plodded ahead at a barely perceptible pace. Very few Bushmen remain in South Africa, or blackfellows in Australia, and these have probably survived by grace of living in a desert and a remote island respectively; but in those days of the end of the Paleolithic the races we distinguish to-day must have been more equal in numbers. The point of this effort to ignore the present scene, and instead to restore that of 10 millenniums ago, is to give these now negligible races their proper significance. When they and possible others stood on more equal terms with those which dominate to-day, the whole species would have presented an appearance of even greater diversity than at present, and this very diversity is an index of the age of the species itself, because races can not have appeared overnight.

Races seem to have formed almost entirely as the result of random evolution. It is conceivable that the tropical sun was an influence in establishing dark skin in the possessors of that feature, and woolly hair as well. If so, it was certainly a long process, too gradual a one to have affected the Indians of tropical America over many thousand years. But geographic isolation, the simple separation of groups descended from the original *Homo sapiens,* was probably the most important factor. Such groups changed slightly but continuously, by nature's laws, and being separated geographically, they tended to drift aimlessly apart in physical form as well, becoming racially diverse. Bagehot, the economist, once suggested that when man was new his meager culture allowed

natural selection to act powerfully upon him, leading to the rapid development of races. This is a poor hypothesis all around; natural selection would affect the functional development of his legs, etc., but selection would actually tend to prevent racial differentiation. There is no real reason to think that there was irregularity in the speed of racial development, or anything except an even increase in diversification, which reached a maximum about ten thousand years ago.

The process probably took a long time. The only sighting point by which we can judge its pace is the beginning of the Upper Paleolithic. The first unquestioned *Homo sapiens*, the Cro Magnons, demonstrate: (1) that there has been no progressive racial development, as far as can be seen, in some 30 millenniums, and (2) that the men of that time were hardly more primitive in an evolutionary sense. In Europe, the Cro Magnons and related types were purely "white" in character, showing that this racial stock, at least, was fully developed and by no means in any embryonic stage. And there is some evidence from other skeletons of comparable age that the Negro and Mongoloid stocks were equally well established. Furthermore, the native Australian of to-day is infinitely more backward in form than were these ancient Caucasians; indeed the fact that the most primitive branch of the species that we know of should be found in a living race rather than an ancient fossil emphasizes again our ignorance of early stages of *Homo sapiens* development.

Now, if no material change in the degree of racial differentiation can be observed in the time from the present back to that which immediately follows the disappearance of the Neanderthals, then it can hardly be denied that the development of all the races out of a common stem must have taken a period several times as long as this one. Even the time when the now archaic Australian, chinless and small-skulled, and with beetling brows and protruding face, represented the forefront of *sapiens* development must be relatively remote. (Galley Hill and the other geological hoboes were more advanced than he.) So from this consideration alone, it would appear that *Homo sapiens* must go back as a distinct species to the middle of the Pleistocene at least, and probably much further. This being so, it is difficult to believe that the Swanscombe skull can have belonged to some other species. And certainly if for these additional reasons the Galley Hill man, who has about the same putative date, can finally be accepted, then the age of *Homo sapiens* must be really great indeed.

ON THE VALUES IN CULTURE

By Dr. MELVILLE J. HERSKOVITS
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MANY reasons have been advanced to account for the wide-spread critical discussion of our political and social system during the past year or two, especially the search for ultimate values and understandable goals by which to order our lives. That the war has had an unsettling effect on our thinking is self-evident; and this is the reason most often brought forward by those who attempt to account for the phenomenon. Yet in itself the war is not enough, for two decades ago a war of equal magnitude failed to produce either the kind of questions or the intensity of questioning of institutions and ways of life which confront us on all sides to-day. Mr. Archibald MacLeish has suggested[1] that blame must be laid on the scholars and writers for the current uncertainties reflected in scepticism as to the ends of democracy and the meaning of "an American way of life," and questions raised concerning the kind of world order that is to be sought and the sort of social and economic system that can best function so as most effectively to further human happiness. That blame may not go unrecognized, though to lay it is also not enough; for the confusion of issues and aims is too widespread to refer to such *ad hoc* explanations. We must be alive to the deeper currents, which, unheeded these many years, have affected the movement of thought in our society in the same way as we can see such currents to have influenced other societies than our own, or to have been significant in earlier periods of our own history. To emphasize that such deep currents do most of their work before they bubble to the surface is merely to underscore the importance of understanding their nature and significance when they appear in our lives.

An analogy to be drawn between our present situation and the experience of many primitive peoples during the initial phases of their contact with European colonial expansion may be helpful in aiding us to comprehend the urgency of our present quest for values. The explanation of the reaction to conquest of such folk is sometimes phrased by the native peoples themselves in terms of the superior strength of foreign gods; sometimes in terms more familiar to our own way of thought. This latter point of view, for example, is expressed by a proverb of the West African Dahomeans, which says: "War never goes against the Whites, for they have the cartridges." Whatever the native reason, it is not difficult to understand why primitive peoples so often become demoralized at the onset of an assault by an aggressive, differing ideology that does not neglect to make the most of the sanctions that derive from the greater effectiveness of their armaments. And it is just this situation that is to-day faced by those who, in our society, are witnessing the underlying values of their own political and social system assailed by an opposing ideology which validates the way of life based on it by a vaunted superiority of power.

Our analogy holds further, and in some detail. We may consider, for example, the techniques of aggression that have been employed by European governments during the years their empires were building. In some parts of the world, of course, it was merely a matter

[1] "The Irresponsibles," *The Nation*, May 18, 1940, and "Post-war Writers and Pre-war Readers," *The New Republic*, June 10, 1940.

of establishing an administration to rule unresisting tribes. In a far greater number of cases, however, control over a reluctant people was preceded by an infiltration of European nationals—missionaries and traders, in the main—who, having settled in the far parts of the earth, became, perhaps unwittingly, the instruments of expansion. Sooner or later, certain prerogatives claimed by these persons came to be resented by the natives; protest eventuated in mistreatment or death of the Europeans; a punitive expeditionary force was dispatched; and the members of what had been an independent, local group found themselves members of a world empire. A third technique was of a similar efficacy; in these cases a group who were the rivals of those in power were encouraged to appeal to a ruler across the far waters for aid in establishing a régime of their own. In most instances, a protectorate followed on aid given, with eventual absorption as a colonial possession.

It is obvious that these are precisely the methods that have been employed in recent years by the totalitarian governments. The case of Ethiopia is a marginal one as concerns attitudes toward these events, since here it was a question of African expansion. But when in Albania, Czechoslovakia and Poland the method of rescuing an oppressed minority—the equivalent of the traders and missionaries among primitive peoples—was employed to implement territorial aggrandizement; or, as in Spain and Rumania, a faction other than that in power was aided in establishing itself as a prelude to physical or ideological infiltration, it began to be realized that what was possible in the remote corners of the world was also possible near to home. And those who in Europe experienced the overthrow of their countries and the accompanying attack on their traditions, or those who looked on at these events from afar, unable to stem the hostile drive, experienced the same sense of frustration that primitive folk experienced as they were absorbed into the empires of Europe and America.

As far as our own society is concerned, this kind of reaction is discernible in most of the questions that, though to-day asked more often and with greater insistence than in earlier years, have been increasingly raised ever since the onset of fascism eighteen years ago. In essence, they are to be subsumed in the question, "Can democracy work?"—a question that has appeared with ever greater frequency as the totalitarian governments, pressing their ideological warfare, have come to be recognized as less and less amenable to the international procedures that had rooted more deeply in our thinking than we had realized. It must also be remembered that an increasingly important precept in our belief has concerned efficiency in the industrial field. Yet in organization for war, and what seems to be organization for survival itself, nations which are openly hostile to our manner of life have manifested a degree of efficiency that has seemed impossible to achieve by those whose values are under attack.

Let us turn again for a moment to those underlying currents of thought, already referred to, whose power has gone unrealized but which have, nonetheless, always been potent in the historic stream of our culture. One of the proudest achievements of our civilization is the development of the scientific approach to the problems of life. Yet the essence of a philosophy based on the scientific method is constant questioning, continuous analysis, never-ending scepticism. Students of human civilization have with others given themselves to this stream of thought, and since the turn of the century all cultural values have been subject to constant investigation. This is in sharp contrast to what obtained before the turn of the century, when our

culture had achieved a condition of stability that was only beginning to be disturbed. At that time, there were few doubts in the minds of scholars, and less among others, to disturb the conviction that our own way of life was superior to all others. Varying civilizations were coming to be known, but knowledge of them was principally useful as documentation of the hypothesis of an evolutionary development of culture, in terms of which the traditions of Euro-American societies were held to be the flowering of human experience in much the same way as man himself was held to represent the ultimate product of biological evolution.

As time went on, however, and more and more knowledge of other civilizations became available, this complacency began to be challenged. The defects in our own way of life were coming in for ever wider recognition; the adjustments made by individuals and groups constituting other societies came increasingly to be stressed. The theory of cultural evolution was the chief object of criticism, and with it the point of view that human civilizations could be evaluated on a scale of better and worse. By the end of the last war, reaction to this had reached its peak in the denial of the existence of all laws of social development. This position, and the related stress on the impossibility of evaluating cultures at all, received what was perhaps their ultimate expression in the following passage:

> If inherent necessity urges all societies along a fixed path, metaphysicians may still dispute whether the underlying force be divine or diabolic, but there can at least be no doubt as to which community is retarded and which accelerated in its movement toward the appointed goal. But no such necessity or design appears from the study of culture history. Cultures develop mainly through the borrowing due to chance contact. Our own civilization is even more largely than the rest a complex of borrowed traits. The singular order of events by which it has come into being provides no schedule for the itinerary of alien cultures. Hence the specious plea that a given people must pass through such and such a stage in *our* history before attaining this or that destination can no longer be sustained. . . . In prescribing for other peoples a social programme we must always act on subjective grounds; but at least we can act unfettered by the pusillanimous fear of transgressing a mock-law of social evolution. Nor are the facts of culture history without bearing on the adjustment of our own future. To that planless hodge-podge, that thing of shreds and patches called civilization, its historian can no longer yield superstitious reverence. He will realize better than others the obstacles to infusing design into the amorphous product; but in thought at least he will not grovel before it in fatalistic acquiescence but dream of a rational scheme to supplant the chaotic jumble.[2]

The recognition of the impossibility of evaluating different cultures is to-day firmly established, and represents a great advance toward clarity of thought as concerns the nature and functioning of human civilization. Yet it would nonetheless seem that the pendulum, in swinging toward the position that it is impossible to evaluate differing cultures, has overshot its mark, since it has caused us to overlook how important are the values of a given culture to the people who live under it. Our civilization may indeed be recognized as in no way inherently superior to another when the two are compared in terms of what each means to its carriers; but this does not signify that every body of tradition is not regarded by those who live according to it as embodying the best way of life for them. And this is why the imposition of a foreign body of custom, backed by power, is so distressing an experience. A people may recognize never so clearly that their own customs are best for them, yet no matter how deep their conviction of this, it is supremely difficult for them to meet the immediate argument posed by the possession of superior force.

Folk thus challenged are, moreover, caught between two conflicting points of view after their secondary adjustment to

[2] R. H. Lowie, "Primitive Society," pp. 440–441.

conquest has been achieved. They may recognize certain benefits from the situation in which they are subject to a foreign ruler, yet it continuously rankles that the direction of their own affairs has been taken away from them. They may recognize certain values in the ideology being pressed on them, or to which they are otherwise exposed, and yet can not but feel that for them their own way of life must be best. An example may be given from West Africa, as an instance of a point of view that could also be cited from many other parts of the primitive world. To the objective observer—at least, to the objective observer from our society—there can be little doubt that the imposed rule of the French and British empires has brought many material benefits. Slavery has been put down, and human sacrifice, and warfare; and it is thus possible for a man to live and trade where he will without fear of losing his personal liberty or his life. The introduction of European medicine has gone far to reduce the many deaths in childbirth, infant mortality and such pernicious and wide-spread diseases as sleeping-sickness, leprosy, and the like, which prevailed in earlier days. Granting the economic exploitation of the natives, it is at the present time neither as direct, as brutal nor as extensive as was that of the displaced native dynasties. Yet despite all this, the native African speaks longingly of older times. He will grant that much has been brought him by the European; yet he will nevertheless, when speaking frankly to one not connected with government, missions or trading companies, express a nostalgia for the days when European control was not present, if he is an old man; or, if he is young, look forward to experiencing freedom from that control. There is, indeed, some reason to feel that the concept of freedom should be realistically redefined as the right to be exploited in terms of the patterns of one's own culture.

It would seem that a change of direction in our thinking is called for. Those who are seeking to understand the nature of human civilization and its effect on the men and women who live under it must separate the evaluation of different cultures from the problem of value in culture. Granting that our own body of tradition is but one of many such bodies—just as we to-day recognize that man is but one unit of the biological series—it must not be forgotten that our society has developed values whose importance for us must be recognized and sustained if we are not to be bested in the ideological struggle that goes on about us, whether or not physical conflict accompanies it. Such analyses of fundamental values in our life as that contained in the recent discussion by Professor Carl Becker[3] indicate the kind of realization our society must come to, and quickly. It must be made clear that this does not imply that the constant questioning which is the essence of the scientific approach need be given over, or that we must abandon the constant search for better methods of social and economic adjustment, or the struggle against the inequalities and injustices that mark our social order. But in terms of the present world situation, we must clearly understand that it is possible to reaffirm in positive terms the fundamental tenets by which we live, even while we recognize the shortcomings in the organization and functioning of our society. On the ideological front, such a realization is essential if the values and goals by which we order our lives are to be maintained in the face of the present assult on them.

[3] "Some Generalities that Still Glitter," *Yale Review*, Vol. XXIX, No. 4, summer, 1940.

THE BACKGROUND OF MODERN VEGETABLE CONSUMPTION

By WILLIAM KLING

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SOME vegetables have been used as food since ancient civilized days. However, compared to modern diets, the diets of the mass of people in most parts of the civilized world formerly contained more cereals and fewer vegetables, fruits and meats. One need go back only a few centuries in Europe to find cereal foods the most important part of the diet. Bread was the staff of life. Meats and their products were consumed in quantity only by the wealthy, although fish were eaten in large numbers around coastal areas.

Consumption of vegetables, such as onions, cucumbers, cabbages, leeks, beets, radishes, turnips, cauliflower, lettuce, watercress, asparagus, parsnips, some types of beans, green peas and eggplant, may be traced to early Egypt, China, India and Asia Minor.[1] The Egyptians, Hebrews and Greeks in their literature note the use of cucumbers and peas, and the use of cabbage is about as ancient as history itself. We know in particular that the Romans had under cultivation a wide variety of truck crops,[2] although consumption of these crops was probably quite limited.

During the Medieval Period in Europe few vegetables were consumed. The ordinary man sought his food primarily in bread and other cereal foods. Some fish, meat and meat products were consumed by him when available. In season he used a few common vegetables such as onions, turnips and cabbage. But it is probable that vegetables played only a very minor part in his diet. Consumption was limited to the few crops that were known and to the local seasons and areas of production because transportation and storage were inadequate. Further, the value of vegetables in the diet was not realized, and for some time the general belief existed in England that they were harmful. The rich ate a wide variety of food, including meats, wine, fruits, dairy products and spices, but vegetables were conspicuous by their absence. The English peasants consumed "black bread, milk, cheese, eggs and occasionally bacon or a fowl,"[3] and fish. The quality of food was extremely low. Vegetable consumption was at a minimum.

But as early as the fourteenth century signs of increasing consumption appeared in Italy, Flanders and France. With the breakdown of the feudal economy in these countries cities grew, transportation developed and knowledge spread.

New varieties of vegetables were introduced from distant lands. Although consumption lagged in certain parts of Europe, by the end of the seventeenth century in many areas a variety of vegetables were consumed in moderate quantities. Demand increased particularly for commercial vegetables because of the shift of large sections of the population to commercial and industrial pursuits which discouraged home farming. Many vegetables were soon shipped into the cities from nearby market gardens.

[1] The Bible and other ancient works mention many vegetables. See Yearbook of Agriculture 1925, p. 313*ff* and 1937, pp. 171–574.

[2] Numerous vegetables were listed in the "Edict of Diocletian."

[3] J. C. Drummond and Anne Wilbraham, "The Englishman's Food," 1939, p. 51.

The New World made its contribution at this time by introducing maize, "Irish" potatoes, sweet potatoes, tomatoes, some beans, pumpkins, squashes and green peppers. The "Irish" potato was the most important of these crops. It soon had a welcome reception awaiting it in the poorer countries of Europe, such as Ireland, where it was introduced about 1650. By contrast, in its native America and in England it did not achieve popularity for another century. Most other American truck crops were neglected for some time; the tomato was not cultivated except as a novelty until about 1830, although it earlier achieved some use in Italy.

As the commercial and educational revolution reached its full bloom, cultivation and consumption of truck crops became more widespread. By the eighteenth century the many towns and cities that were developing on most parts of the Continent were supplied with vegetables by nearby market gardens. After a lag of some years widespread cultivation developed in England also. Those who could afford to buy vegetables now found celery, cauliflower, potatoes and savoys to supplement the few established and available vegetables, such as cabbage and onions that had long been in use.

But consumption of these foods, which were, in many cases, luxuries, was confined mostly to the rich. In England, the poor were more undernourished at this time than in medieval days. The industrial revolution, the factory system and the enclosures had crowded them into slums. Wages were sufficient in many cases only to buy bread and potatoes. Very little meat and few vegetables were eaten by the majority of the people. By contrast, in manorial days, the peasant had had some subsistence from his land and his lord. Vegetable consumption had increased for the growing middle class and the wealthy but only slightly for the poor.

It should be noted that consumption of vegetables was still limited by other factors besides the inability of the common man to pay for them. Vegetables could be secured only in summer months because of inadequate transportation and storage. Their value as a food was still not fully appreciated. Many crops were unknown.

Yet with the passage of the reform laws during the nineteenth century, the condition of the poor began to improve and the consumption of vegetables increased. The technological and scientific advances of the twentieth century, coupled with the increased purchasing power of the people, caused vegetable consumption to rise to higher and higher levels. But many sections of the population still remained woefully undernourished.

II

American Development

The early American settlers learned cultivation of many new crops from the Indians. The colonists were forced to subsist to a large extent on these new food crops for lack of other sustenance, but also grew to recognize their value. As noted, by the seventeenth century, many American vegetables had found their way to Europe and were soon prime crops in some countries. The "Irish" potato derives its name from its wide use in Ireland even before it was considered important in its native America. On the other hand, many Old World vegetables soon found important places in American agriculture.

In Colonial America, crops were generally cultivated for local or home consumption, although some cereal crops were exported. Most farmers had their own fields of wheat, barley, oats and rye, and their own pig pens and vegetable patches. Households were largely

self-sufficient and obtained only a small fraction of supplies like salt and flour from outside the home and then mostly from local producers. Practically all vegetable supplies were secured from the home garden.[4] In these gardens a variety of vegetables were grown, such as lettuce, beans, cabbage and potatoes; the more hardy were stored. There was little commercial production and what there was took place on a local basis. Consumption was largely limited to the local season of production and only to those vegetables which could be grown locally.

During the nineteenth century, the development of urban communities and rail transportation in America caused a great increase in the commercial production and availability of many agricultural products.[5] The increasing tempo of the industrial revolution and its corollary, the urbanization of population, brought many changes in the method of obtaining food supplies and in the type of food eaten. Immigrants came to this country by the million. The nation began to do its work in factories. Most workers did not have the time or the land to grow their own food and they became dependent on others for supplies. Specialization marked the trend. Part-time farming and gardening was practiced by some who had their homes on relatively cheap and spacious land, but those who settled in the large densely populated cities looked to others for their food. By the middle of the nineteenth century, large cities that specialized in industrial occupations were taking great quantities of food from surplus-producing agricultural areas.

Although the division of labor within the new specialized economy created a need for commercial food production, the commercial production of vegetables lagged. This lag was due in part to the ease with which a large part of the population could grow its own vegetable supplies in season. Also, although vegetable shipments from relatively nearby areas were possible, technical facilities were still inadequate for storage or for shipment of perishables from distant areas. Neither did food habits, dietary knowledge and modes of life create a great demand for vegetables. Further, a relatively low standard of living did not allow for mass consumption.

But the discovery of canning in France altered this situation somewhat. Nicolas Appert published his treatise on canning in 1811 titled, "The Book for All Households on the Art of Preserving Animal and Vegetable Substances for Many Years."[6] Foods could now be preserved for off-season use and for use far from the areas of production. By 1820, crude and canned goods were produced commercially on a small scale in the United States. The Civil War gave impetus to canning in efforts to supply the armies with food. But a method of supplying foods out of season and far from the areas of production was bound to expand without the war stimulus. By the end of the nineteenth century, canned vegetables, particularly tomatoes and corn, were widely consumed. Commercial areas of canning production, in places far from the consuming market, developed, and the localization of truck-crop production was modified. Vegetable consumption increased.

By the end of the nineteenth century, the same technological revolution that

[4] It must be noted that even in home and farm gardens the variety of vegetables was limited and supplies could only be secured in season. Tomatoes, one of the most valuable vegetables to-day, were not widely used until about 1830 and could be secured only in about two or three months of the year. Many common vegetables and vegetable uses of to-day have been introduced only in the last twenty-five years.

[5] Richard O. Cummings, "The American and His Food," 1940, Chapter V.

[6] "Le Livre de tous les Menages ou l'Art de Conserver pendant Plusieurs Années Toutes les Substances Animales et Vegetables."

had developed canning resulted first in the discovery of the railroad and then in the perfection of a refrigerated freight car. This made the distant shipment of perishables possible and therefore widened supply areas.[7] First used to ship meats, it was a relatively short time before refrigerated freight cars were used to ship fresh vegetables from distant areas. High prices could be obtained by shipping vegetables to large markets in seasons when local supplies were not available; growers located far from consuming centers increased production. High prices offset high freight costs. Large corporate vegetable farms developed to compete with the traditional family unit. Another impetus was given to consumption.

And with the development of research on nutrition, the value of vegetables in the diet became common knowledge. In addition, the increase in purchasing power made other than subsistence foods available. New uses for old vegetables were found and other vegetables were drawn out of relative oblivion. The population worked less strenuously. Machine power replaced hand power and people required fewer calories. "Lighter foods" like vegetables were consumed in greater quantities. At the same time the urbanization of population continued while population itself increased. The consumption of commercial vegetables showed marked growth. Rail shipments of vegetables increased steadily from no shipments at all to the hundreds of thousands of carloads shipped to-day. Recently the motortruck has added greatly to the means of supplying vegetables.

To-day, although many consumers are ill fed, most markets are amply supplied with sufficient vegetables in all seasons. Produce arrives by rail, boat, truck and wagon. In certain cases, market controls have been instituted to modify the gluts of winter-producing, as well as summer-producing areas. The major part of the nation lives in urban communities and looks to commercial producers for vegetable supplies. Farming is largely specialized, thus creating a demand for crops other than those specialized in. Food habits and lower prices favor vegetable consumption, as well as a host of new uses such as quick-frozen vegetables and vegetable juices.

Apparent per capita consumption of fresh vegetables, excluding potatoes and sweetpotatoes, increased from an average of 133 pounds in 1920–24 to 164 pounds in 1935–39. Apparent per capita consumption of canned vegetables showed an even greater rise. From an average of 14 pounds consumed in the crop years of 1919–23, consumption increased 54 per cent. to 22 pounds in 1934–38. Although consumption figures are not available for earlier days, it is safe to say that vegetable consumption has had a continued upward trend through the years. If the advice of nutritionists is followed, this trend should continue to much higher levels.

[7] See Wells A. Sherman, "Merchandizing Fruits and Vegetables," 1928, pp. 3–45.

THE SPECIMEN FETISH

By W. L. McATEE

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THE statement, "At least one specimen of every form listed has been examined by some qualified ornithologist," is typical of modern formal lists of birds. While recognizing that specimens must be collected to gain particular definite bits of information or to settle certain questions of identity, the writer would point out that specimens are not necessarily infallible vouchers of occurrence and that in the last analysis the main consideration is the integrity and exactitude of the collector or observer.

The utility of a specimen to the compiler of a list depends upon the label. A label may be attached to a wrong specimen in early stages of its preparation, or may be misplaced later. Aside from such hazards, labels may be deliberately switched, their legends may be untruthful or they may be wholly faked. Let any one who does not believe that such things occur glance through files of the minor ornithological magazines of the 80's and 90's.

Labels, in fact, have no absolute, but only a qualified value. And what is it that qualifies their reliability but the integrity of their writers? The thing that finally must be accepted or rejected is some individual's word, and the largest factor in the decision will be what is known of that person's dependability.

Waiving questions of subspecies, statements about the distribution of which are 90 per cent. or more rationalized anyway,[1] the recording of species of birds need not always be based on specimens, granted there are enough honest ornithologists. Would such a scientist's word need backing that he had seen an American egret, a marsh hawk, an English sparrow or a starling? or for that matter any of a majority of our birds? Must a scissor-tailed flycatcher or a magpie, unmistakable species, be collected to prove that they occurred somewhere far away from their normal ranges? If the observer's word without a specimen is to be rejected, how does it so increase in value as to be accepted by being written on a label? The whole question of the credibility of records is merely the integrity of the observer.

One might mention names to illustrate, pro and con, but that would be invidious. It is evident, however, that some ornithologists are too enthusiastic and "see things where they ain't," others are too credulous and lend the weight of their belief to statements that otherwise would get no hearing. Some are pundits and can not resist at least once in a while attempting to put something over by the sheer force of their authority—"If I say it's *tropicus* it is *tropicus*." Others are just plain run-of-the-mine bird students trying their best to learn correctly and record aright, and their word alone is as good evidence as can be obtained. The nature of these men is such that anything they seriously record will be based on critical investigation. Integrity and exactitude they have—all that is required.

Again let the writer say that he knows there are many questions that can not be settled without resort to specimens, or without collecting additional material, but that is not admitting that entries can not properly be made in a local list without specimens to back them up. When making bird lists for publication,

[1] That is, subspecific designations in bulk are copied from "authorities" and do not rest on specimens. Even the specimen identifications, as a whole, have to a large extent involved material other than breeders from the breeding ground, and thus not wholly valid for subspecific determination. That part of the science is intricate and can well be left to advanced systematists. Local lists would be a great deal more dependable than most of them have been if they ignored geographical races.

he long carried a collecting pistol with which to bring to hand any *Empidonax* that would not tell its name, any thrush whose persistent skulking in the shadows prevented identification, or any apparent rarity. The writer well knows that many a female redstart or yellowthroat, seen in the play of light and shade, has been mistaken for something else until shot and retrieved. But ornithologists of integrity do not list merely glimpsed birds; they record species only when they have studied them enough to be sure. If not prepared to take specimens, they will leave the small sandpipers, warblers in fall plumage and other uncertainties to the collector. But that is not to say that their sight records are valueless. In truth records not backed by specimens make up the bulk of all that is said about habits, migration and local distribution in our ornithological publications. Why insist on a specimen as the sole criterion for admission of a species to a list when as a rule most of the information given about that same species is not based on specimens?

The writer wishes to contend against any urge there may be toward the resumption of general collecting. That practice has had its day in skin, as well as in egg, collecting. The need still acutely felt for certain material proves that general collecting does not satisfy specific wants. What is required is specialized collecting intelligently planned to bring just what is needed.

Collecting is necessary in the training of those who intend to go deeply into ornithology, but not for the average observer or field-glass ornithologist. If collecting birds ever attained the popularity that once attached to oologizing and attracted as numerous disciples, keen on long series of specimens, it might have a very serious effect upon some of the less common birds.

Insistence in collecting everything also might well have results harmful to the avifauna, regarded strictly as an object of scientific research. It might help to keep rare species in that state or even contribute to their extirpation. It might interfere with extension of range of uncommon forms by killing off the pioneers. It might prevent the establishment of mutants (such as Townsend's bunting probably was) or the development of new forms by hybridization (such as those between *Vermivora pinus* and *V. chrysoptera*).

For the welfare of ornithology itself, collecting can be abused; it should have a proper place but need not be exalted into an indispensable adjunct to the compilation of authentic local lists. So far as species are concerned, in very many cases, the requirement that inclusion be based exclusively on collected specimens is absurd.

In closing the writer would say that he submitted the first draft of this paper to ornithological friends and was surprised to find that it was considered an attack on the validity of collecting. It was not so intended and has been modified in an effort to make clearer its message as summarized in the preceding paragraph. At the same time it should be realized that high ideals and conservative practices must be adopted if collecting is to be prevented from falling farther out of grace. The writer can no more agree with the collector who thinks that all the ivory-billed woodpeckers, for instance, should be collected and preserved in museums, than with the sportsman who thinks that the plovers and prairie chickens can not be perpetuated and that the gunners might as well have the fun of killing them. Ornithologists must in some degree love birds, naturalists to some extent must revere nature, and their feelings in those respects should make them defenders of threatened species, which can be preserved, if at all, by the best protection we can give them in their native environments.

BOOKS ON SCIENCE FOR LAYMEN

SIMPLE AS WALKING?[1]

INCREASING numbers of young men are learning to fly. In 1939 the Civilian Pilot Training Program was inaugurated by the Civil Aeronautics Administration as an experiment in the training of civilian pilots through educational institutions. Many thousands of pilots have been trained. At present this program is a part of the war effort to secure and train flyers for the military services. Aviation leaders predict that after the war there will be a tremendous increase in civil flying and that learning to fly will be as easy and simple as driving an automobile.

Cloyd P. Clevenger, pilot and flying instructor for 23 years, maintains that flying is as simple as walking if one will only take the time to learn it properly. He has crystallized his own experience in "Modern Flight" to tell the student in simple words how to fly, from the time he first steps in an airplane through the elementary, intermediate and advanced stages. The book is intended for one who is actually learning to fly, who has an airplane and instructor, and parts of the book are addressed to the instructor. The book is a guide book for supplementary reading during actual instruction.

The book is written around the small civil airplane or primary trainer. It is not claimed that one can learn to fly by merely reading the book. Air-minded persons as well as armchair pilots will, however, find the book interesting reading, and even those who question whether the process is as simple as walking may find a vicarious thrill in studying the instructions and drawings.

HUGH L. DRYDEN

[1] *Modern Flight.* Cloyd P. Clevenger. Illustrated. ix + 294 pp. $2.95. 1941. Noble and Noble.

OUT OF THE TEST TUBE[1]

QUITE possibly the chemist never lived who was more enthusiastic than Professor Holmes about his subject. Enthusiasm is notoriously contagious, and the unique style of this author goes a long way toward making his book a success. Especially noteworthy are the chapters "The Fall of the House of Uranium" and "Silks and Cellulose." The returns which may be expected from adequately directed research are effectively exemplified by indigo and novocaine. Much of the book is so good that one regards it with a feeling of regret that time was not taken to make it very much better. For it is marred by a superficiality which is all too frequently apparent. The case for chemistry (and for its endowment) is sufficient without embellishment. But, like the Norwood builder, Professor Holmes attempts to improve an already perfect case.

On page 44 we are told of a "very considerable cooling of the lungs caused by evaporation of ether." Surgeons do indeed refuse to use ether under certain conditions, but the reason is pharmacological rather than physico-chemical. First, it may be noted that if the cooling effect were of any significance, the preceding heating effect would be even more severe, inasmuch as the rate of condensation of ether during anesthetization is greater than the rate of vaporization after the ether mask has been removed. That the quantity of heat is small can be seen from the concentration of ether in the blood during anesthesia (0.15 per cent.) and the latent heat of vaporization (90 calories per gram). It is in fact negligible compared with the heat abstracted from the lungs by the vaporization of water during normal respiration.

[1] *Out of the Test Tube.* Harry N. Holmes. 3rd ed. Illustrated. 305 pp. $3.00. 1941. Emerson Books, Inc.

It probably makes no iota of difference to the layman, but (p. 18) it was Bertholet, not Berthelot, who flourished in the eighteenth century and pioneered in the study of chlorine. But our informed layman will be positively pained, after being good-naturedly scolded (p. 151) for saying "nitrocotton" instead of "cellulose trinitrate," to find the author indulging in terms such as "prussic acid gas" and "nitroglycerine." And many readers will describe recent uses of tear gas against "mobs" by adjectives other than "merciful."

The achievements of E. I. du Pont de Nemours and Company are many and notable, but *waterproof* Cellophane (p. 154) is not among them.

Any one attempting to preserve the aroma of his ground coffee for many weeks by adding oat flour (p. 196) will be disappointed, as the deterioration of the aroma depends on factors in addition to the oxidation of coffee-oil; notably the polymerization of furfuryl mercaptan.

It is of course impossible to state categorically that the book was consciously intended as an advertisement; one can only say that if it had been so intended, its contents would have been much the same. A number of passages might be quoted in support of this contention, but one (p. 282) must suffice: "The social benefits of ownership of attractive homes by more millions of people will be great. Home life will be more attractive, an interest in beauty everywhere will be fostered, and communism will be discouraged."

THOMAS B. GRAVE

THE LIFE OF A TELESCOPE MAKER[1]

JOHN ALFRED BRASHEAR is probably best known as a maker of astronomical instruments, but he was more than a mere technician; he was a man who helped to mold thought not only in the field of astronomy but also in the field of education.

His life could never have been lived in any other country except the United States, for he was born in circumstances which made it very improbable that he could attain to as high a station as he held. It is seldom that any man without even an ordinary school education can become an outstanding figure in any scientific field and certainly very few aside from Dr. Brashear have ever attained the distinction of heading a university. He started out as a mechanic, but because of his interest in astronomy, decided to make a telescope. With this as a start, he interested others in astronomy and began to make telescopes for others. Fortunately, several businessmen, among them Andrew Carnegie and William Thaw, became interested in his work and helped him in the establishment of his instrument plant. Never a good business man, with their help he made a business success.

The authors have succeeded in portraying him as a person of wide interests and unusual ideals. Rarely does a scientist have as sympathetic biographers. If all the books in the "Pennsylvania Lives" series succeed in doing as excellent a piece of work as has been done here, the series as well as this one volume will be a great contribution to American biography.

D. B. YOUNG

[1] *John A. Brashear.* H. A. Gaul and R. Eiseman. viii + 220 pp. $2.25. 1940. Pennsylvania Lives Series.

BEHAVIOR OF THE ADOLESCENT[1]

IN 1932 the Progressive Education Association set up a Commission on Secondary School Curriculum, in an attempt to clarify and think through some of the basic problems of secondary education. In addition to various commit-

[1] *The Adolescent Personality.* Peter Blos. xiii + 517 pp. $3.00. 1941. D. Appleton-Century Company.

tees organized under the commission to study the subject-matter of the curriculum itself, there was also established the Study of Adolescents, which concerned itself with the understanding of adolescents themselves, in their life outside as well as inside the school and in their personal and social contacts. This committee engaged the services of experts in many fields—educators, psychologists, psychiatrists, physicians, social workers, even sociologists and anthropologists. For nearly ten years it has been busy, studying young people from their entrance into junior high school on through the four years in college. The groups studied have represented a wide range of socio-economic, cultural and geographical status; out-of-school youth were studied also; and, recognizing that the adolescent is not a species sui generis, the individual's early life and family history were also investigated.

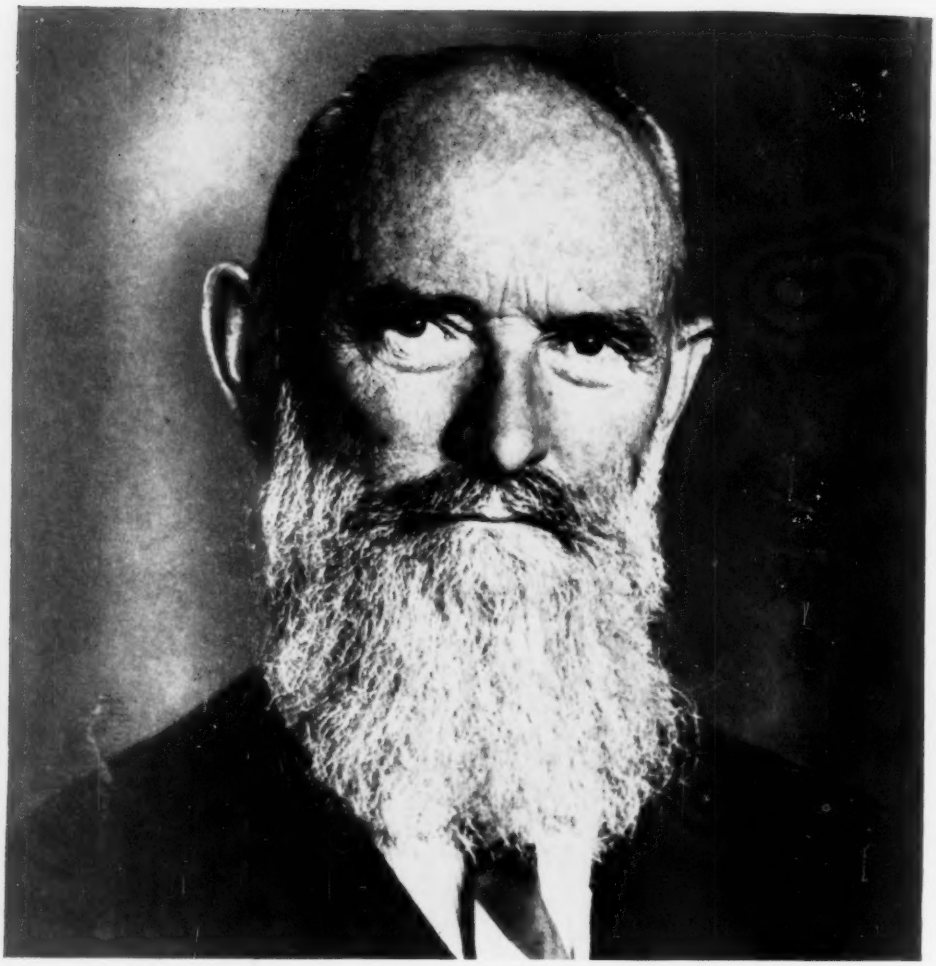
The results of this most intensive investigation of adolescence ever undertaken are beginning to appear. This book is one of them. From over 600 cases it has taken two, which are presented in considerable detail. We have here extensive case histories of Betty and Paul, including verbatim reports of interviews with the subjects themselves. The material is interpreted and correlated, and on the basis of its findings the author develops a theory of adolescent development, which he then tests upon two other cases, young people who were out of school and at work. The final section is devoted to a brief discussion of education and adolescence.

Though the material uncovered by these studies is not new to the psychologist, there is much in it that will be new and startling to the average teacher, unaccustomed to peering behind the mask of Paul's or Betty's behavior to find the motives actually prompting it; and to the average parent as well, who prefers to forget his own adolescent conflicts, even though all too often they are guiding his reactions to his young son or daughter. The fact that adolescence brings little new, but reawakens old emotions and conflicts whose roots are in infancy; that the adolescent's behavior, no matter how far fetched it may seem, is but an individual's response to a need; that the parents play an all-important part in shaping the child's personality, and that, too, in his earliest childhood—these things are yet far from being generally known or accepted.

In these days of mass education and departmentalized instruction, to envisage a handling of adolescents as individuals may seem too much to ask of the school. Yet studies such as this make it abundantly clear that, whether we are aware of it or not, it is by and through his personal contacts, with other adolescents, with teachers and other adults, that the youth grows and develops, and is finally enabled to leave childhood behind. Such contacts determine not only his general adjustment but his interests and learning ability as well. In short, the adolescent is an individual, more acutely aware of himself as such than he ever was before or will be again. And only when he is understood and handled on the basis of his particular personality and his individual needs, does he have a chance to develop the best that is in him.

Whether one agrees with all the author's deductions or not—and this reviewer certainly agrees with most of them—this section of the Commission's investigations is well served by Dr. Blos' careful study. The next few years will probably see a drastic curtailment of such educational activities as those represented by the Commission; it is good that we already have such studies as this, which may well be a part of the blue prints for the reorganization of our educational theory and practice which is bound to take place after the war.

WINIFRED RICHMOND



ROBERT BOSCH

German industrialist and manufacturer of the magneto bearing his name, who died on March 13 at eighty-one years of age. The son of a farmer in Abeck, he came from rugged Swabian stock. Dr. Bosch, who opened a small shop half a century ago, became known as a manufacturer and inventor of magnetos, spark plugs, lamps, horns and oil pump devices. His company had branches all over the world and his German plants probably employed 25,000 workers before the outbreak of the present war. In 1906 he introduced the forty-four hour week in his factories and his wages were 60 per cent. higher than those paid elsewhere. This preceded by eight years the introduction of the five dollar minimum scale of Henry Ford. He received his initial technical training at the age of twenty-three when he visited this country and worked with Thomas A. Edison. In 1901 he developed the Bosch magneto and Bosch lamp, which were the foundation of his world-wide reputation. Nine years later he gave $250,000 to the Stuttgart Technical High School for scientific research; in addition to other millions donated to public welfare projects he gave $5,000,000 for building a canal in the Neckar River.

THE PROGRESS OF SCIENCE

THE ANNUAL MEETING OF THE NATIONAL ACADEMY OF SCIENCES

THE seventy-ninth annual meeting of the National Academy of Sciences was held on April 27 and 28, 1942, at the Academy building in Washington, D. C. Because of the war, the meeting was attended by Academy members only and was limited to a discussion of the structure of the Academy in its relation to the government as adviser on problems in science. One hundred and seventeen members were present and participated in a general discussion of the activities of the Academy directed to the mention of a wide range of technical problems on behalf of the government. Many of these problems are confidential in nature and are so treated by the scientists engaged upon them.

The general relation of the National Academy of Sciences, of the National Research Council and of other groups, more recently established by Executive order, to the government were described informally by Dr. F. B. Jewett, president of the Academy, following an analysis made recently by him and published by the Institute of Radio Engineers.

Civilian participation in one way or another in the solution of military problems has come to be taken for granted. It was first given official recognition in the United States when the National Academy of Sciences was incorporated in 1863 by an Act of Congress. The charter of the Academy requires that whenever called upon by any department of the Government, it shall investigate, examine, experiment, and report upon any subject of science or art, the actual expenses of such investigations, experiments, and reports to be paid from appropriations which may be made for the purpose, but the Academy shall receive no compensation whatever for any services to the Government. The Academy is, therefore, recognized as a continuing official adviser to the Federal Government and it must attempt to answer such questions of a scientific or technical nature as are officially submitted to it by members of Government Departments. A permanent channel of communication was thus created, but power to initiate traffic over it rests with the Government and no auxiliary machinery was created whereby the Academy or any other civilian agency might take the initiative in bringing before the Government matters of scientific importance.

Less than a year prior to the entry of the United States into the first World War, a significant step was taken designed to facilitate the use of the channel of communication between the Government and the National Academy. In 1916 the National Research Council was created by President Wilson, and a little later was to play a part in focusing civilian effort on the military problems then arising. The National Research Council was, and is today, a subsidiary of the National Academy of Sciences and, like the Academy, is largely an advisory body only and awaits the assignment of problems by one or another branch of the Government before it can seriously go to work. Moreover, the Council, like the Academy, is not in possession of free money, a corporate laboratory, and other research facilities and is, therefore, not well constituted to conduct research work on any extensive scale.

We turn our attention, therefore, to another agency contemporaneous with the National Research Council, which was created for the express purpose of establishing cooperative effort between military and civilian groups, and which was provided by Congress with funds necessary to create research facilities and to operate them when once created. This agency is the National Advisory Committee for Aeronautics, commonly known as the NACA. The law which created the Committee provides that it shall "supervise and direct scientific study of the problems of flight, with a view to their practical solution," and also "direct and conduct research and experiment in aeronautics." The Committee is composed of fifteen members, including two representatives each of the War and Navy Departments. Throughout its more than twenty-five years of existence, the NACA has given ample testimony of the fruitfulness of cooperation between military and civilian groups, and moreover has provided a prototype as to an organizational arrangement for effecting such cooperative effort successfully.

When, some two years ago, the group to whom I have already referred became convinced that broader participation by civilian scientists in the whole military program was likely to be essential, they regarded the NACA as typifying the

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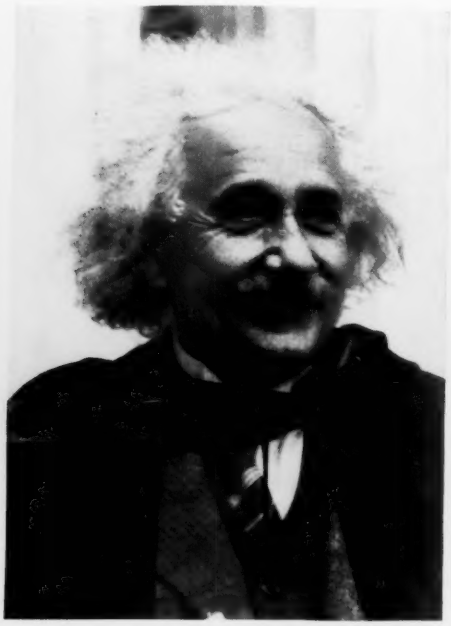
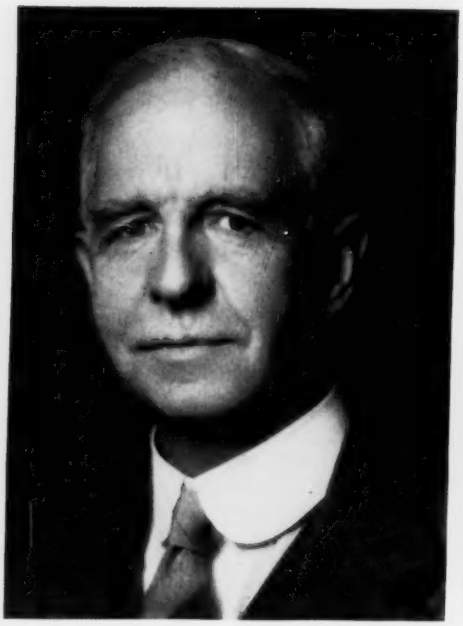


DR. ALBERT EINSTEIN
PROFESSOR OF MATHEMATICS, INSTITUTE FOR ADVANCED STUDY AT PRINCETON.



DR. LYMAN J. BRIGGS
DIRECTOR, THE NATIONAL BUREAU OF STANDARDS.

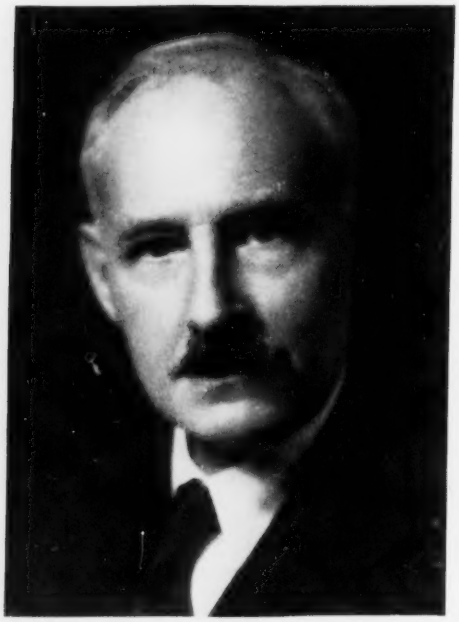
DR. JOHN GAMBLE KIRKWOOD
PROFESSOR OF CHEMISTRY, CORNELL UNIVERSITY.

DR. JOHN T. TATE
PROFESSOR OF PHYSICS, UNIVERSITY OF MINNESOTA, MINNEAPOLIS.

DR. HOMER ADKINS
PROFESSOR OF ORGANIC CHEMISTRY, UNIVERSITY OF WISCONSIN.

DR. PAUL D. MERICA
VICE PRESIDENT AND DIRECTOR, INTERNATIONAL NICKEL COMPANY, NEW YORK.

DR. C. A. ELVEHJEM
PROFESSOR OF AGRICULTURAL CHEMISTRY, UNIVERSITY OF WISCONSIN.



DR. H. T. CLARKE
PROFESSOR OF BIOCHEMISTRY, COLUMBIA UNIVERSITY.

DR. MICHAEL HEIDELBERGER
ASSOCIATE PROFESSOR OF BIOCHEMISTRY, COLUMBIA UNIVERSITY.

sort of organization they would like to see created. A plan was therefore drawn up envisaging a Committee composed in part of civilian scientists and in part of Army and Navy representatives. On the one hand, the Committee was charged with a broad study of the materials of warfare and, on the other, it would recommend and, if possible, initiate such research as it believed to be in the national interest.

The NACA was created in 1915 by an Act of Congress. The somewhat duplicative plan just referred to was submitted to President Roosevelt about a year and a half ago for such action as he saw fit to take. The proposal appealed to him and he decided to create the Committee by Executive Order. This Order established the Committee as a division under the Office for Emergency Management and confers upon them power to take the initiative in many scientific matters which they believed to have military significance. It also directed the Committee to develop broad and coordinated plans for the conduct of scientific research in the defense program, in collaboration with the War and Navy Departments; to review existing scientific research programs formulated by these Departments, as well as other agencies of the Government; and advise them with respect to the relationship of their proposed activities to the total research program. Moreover, and this is especially important, the Order directs them to initiate and support scientific research on the mechanisms and devices of warfare with the object of improving present ones and creating new ones.

The Order contemplated that the Committee would not operate in the field already assigned to NACA nor in the advisory field of the National Academy of Sciences and National Research Council. Parenthetically it might be noted that in this latter field the Academy and Council are currently engaged on advisory work for the Government for which the out-of-pocket expenses alone are at the rate of much more than $1,000,000 a year. A recent count shows that the present personnel of Academy and Research Council advisory committees runs to about 225. These figures will give an idea of the vital part which these fact-finding groups are playing in the present emergency.

In June, 1940, the National Defense Research Committee, more familiarly known as the NDRC, was born. It was constituted of eight members, two of these being high-ranking men from the Army and Navy respectively, five more being civilians well known for their experience in organizing and directing both fundamental and applied scientific research, and, as an eighth member, the Commissioner of Patents.

The Executive Order creating the NDRC

omitted any reference to the biological sciences, and, in particular, to the medical sciences. However, during its first year of operation, experience accumulated to the effect that a broader program of attack would not only be useful but was, in reality, urgently demanded. This realization prompted a second approach to President Roosevelt, with the result that in June of last year he created two new functional groups. One of these was the Committee on Medical Research, to explore its indicated territory in the same manner that the NDRC had been exploring the physical sciences. Then, over and above both the NDRC and the Committee on Medical Research, there was placed the Office of Scientific Research and Development, usually referred to as OSRD. This latter office was placed in charge of Dr. Vannevar Bush, who until then had been Chairman of the NDRC. President Conant, of Harvard, was then made Chairman of the NDRC and Dr. Newton Richards, of the Medical School of the University of Pennsylvania, was made Chairman of the CMR.

In order to insure complete coordination of civilian and military research and development, Dr. Bush, as Director of OSRD, was provided with an advisory council consisting of the Chairmen of NDRC, CMR, and NACA; the Coordinator of Naval Research, and the Special Assistant to the Secretary of War performing a somewhat similar function in that service.

The Executive Orders creating these various committees naturally had to leave indeterminate the question of financial support. They are all subsidiary to the Office for Emergency Management and, like this Office, must look to Congress for the necessary operating appropriation. Thus far the appropriations, while not munificent, have been adequate. During its first year of existence the NDRC authorized research projects which totaled about ten million dollars. At the beginning of its second year, it was granted another ten millions and this was recently augmented by several millions more. To be more specific, the OSRD, during its first year of existence, will guide the expenditure of about twenty millions throughout the whole scientific field.

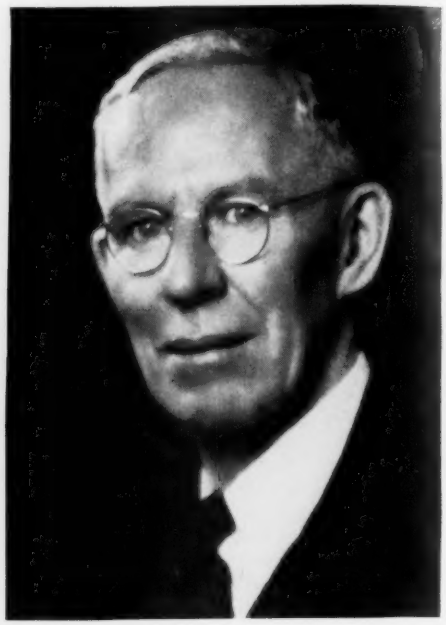
The relations thus sketched by Dr. Jewett were described in greater detail by Academy members and steps were suggested for rendering the Academy more effective in its service to the Government during the present emergency and thereafter.

At the Tuesday morning session the

DR. THOMAS MIDGLEY, JR.
VICE PRESIDENT, ETHYL GASOLINE CORPORATION.

DR. S. A. WAKSMAN
MICROBIOLOGIST, NEW JERSEY AGRICULTURAL EXPERIMENT STATION.

DR. RALPH E. CLELAND
PROFESSOR OF BOTANY, INDIANA UNIVERSITY.



DR. C. H. DANFORTH
PROFESSOR OF ANATOMY, STANFORD UNIVERSITY.

DR. E. D. TYZZER
PROFESSOR OF COMPARATIVE PATHOLOGY AND TROPICAL MEDICINE, HARVARD MEDICAL SCHOOL.

DR. ALFRED M. TOZZER
PROFESSOR OF ANTHROPOLOGY, HARVARD UNIVERSITY.

annual elections were held with the following results:

Foreign Secretary: Walter B. Cannon, Harvard Medical School, Boston, Massachusetts (to succeed L. J. Henderson, deceased).

Members of the Council: For a term of three years commencing July 1, 1942.

A. N. Richards, Medical School of the University of Pennsylvania, Philadelphia, Pa. (to succeed himself).

G. W. Conner, Department of Embryology, Carnegie Institution of Washington, at Johns Hopkins University, Baltimore, Md. (to succeed C. A. Kraus, of Brown University, Providence, R. I.).

Foreign Associate: Robert K. S. Lim, Peiping Union Medical College, Peiping, Kweiyang, Kweichow Province, China.

Dr. Albert Einstein, who was elected foreign associate of the Academy in 1922 as a German subject, became an American citizen in 1940. In recognition of this change in status he was elected a member of the Academy, but with the understanding that his title of foreign associate shall not be disturbed by this action. Fifteen other men, whose portraits also accompany this report, were elected to membership.

At its meetings the National Academy made the following awards: the Mary Clark Thompson gold medal with bronze replica to Sir Arthur Smith Woodward, the distinguished British paleontologist; the Daniel Giraud Elliot gold medal with bronze replica for 1935 to Edwin H. Colbert, of the American Museum of Natural History; the Daniel Giraud Elliot gold medal with bronze replica for 1936 to Robert Cushman Murphy, of the American Museum of Natural History.

F. E. WRIGHT,
Home Secretary

A BRAZILIAN ORIGIN FOR THE COMMERCIAL OIL PALM

THE traditional name "African oil palm" may be misleading, like "Irish potato" and "Jerusalem artichoke." It is known that the oil palm was taken from Africa to the West Indies in the seventeenth century, whence the species was called *Elaeis guineensis*, but an earlier transfer from Brazil to the Portuguese slave-trading settlements in Africa is indicated. The palm grows spontaneously along the coast of Brazil and belongs to the coconut family. All the allied genera are natives of South America. The closely related Panama oil palm, *Alfonsia oleifera*, is compared and illustrated in the *National Horticultural Magazine* for January, 1940.

Elaeis is a handsome, middle-sized palm growing well in southern Florida and producing dense clusters of oval, plum-like fruits. A yellow oil, tasty and wholesome in the fresh state, is obtained from the pulp of the fruits, while the kernels yield a colorless oil, much like coconut oil. West Africa and the East Indies supply most of the palm oils for the United States, amounting to 800,000 tons. A special use of Elaeis oil is in the manufacture of tin-plate. The plea of European nations for a "place in the sun" is chiefly to obtain rubber and vegetable oils.

The introduction to Jamaica, "In Tubs Watered by the Way," as noted by Hans Sloane in 1688, apparently had occurred several years earlier, a full century before Captain Bligh's more famous mission to bring the breadfruit from Tahiti, interrupted by the mutiny on the *Bounty*. The oil palm and the breadfruit now are scattered through the West Indies, but seldom used. The normal inertia of food habits would account for the breadfruit not being adopted by the Negroes, but not for their failure to welcome palm oil, if they had known it in Africa. An aversion would be explained if they met with palm oil on the slave

ships, and had to eat it in a rancid state.

The first unequivocal account of Elaeis, in Bauhin's "Historia Plantarum Universalis," 1650, was from the Gold Coast, where the Portuguese had possession for 160 years, from 1482 to 1642,

MATURE FRUITS
NEARLY NATURAL SIZE.

then the Dutch, later the British. Earlier references to palm oil have been associated with Elaeis, but may relate to local palms with similar oils. Bauhin described a palm called "ady," at San Thome, doubtless Borassus or Hyphaene, with very tall, smooth, swollen trunks, inflorescences tapped for wine, and large yellow fruits yielding a yellow oil that the natives used for seasoning their food and shining their skins.

Early utilization of Elaeis in Brazil may be reflected by Nieuhoff in "Pinkerton's Voyages," recounting the struggles between the Dutch and the Portuguese, from 1640 to 1649. Cassava and oil were noted among food supplies of beleaguered settlements. In a garden at Pernambuco, then a Dutch colony, were "near seven hundred cocoa trees of all sizes, some of them thirty, forty and fifty feet high which being transplanted thither out of the circumadjacent countries bore abundance of fruits the very first year." Palms with large trunks transplant better, presumably from storing more moisture. Brazil has many wild cocoid palms, but only Elaeis would promise a food return to warrant so much labor.

An early Portuguese cultivation in Angola is intimated in Monteiro's "Angola and the River Congo," 1876, at a long-abandoned missionary settlement where "plantations of coconut and oil-palm trees, groves of oranges, lemons and other fruit trees," had been established. The use of tree crops apparently had spread among the natives along the Quanza River, "a delicious panorama of mile after mile of the most beautiful dark forests of high, feathery-topped oil palms," sheltering native huts.

Richard Burton, in "The Lake Regions of Central Africa," 1860, reported the discovery of Lake Tanganyika and a wealth of oil palms. "*Elaeis guineensis* . . . springs apparently uncultivated in large dark groves on the shores of Tanganyika, where it hugs the margin, rarely growing at any distance inland." Several writers have quoted this statement without noting that Burton in "The Lands of Cazembe," 1873, withdrew his identification of the palm. "I found a species on the Tanganyika Lake which produced good oil but the fruit

was like a bunch of grapes, not a spike, as on the West African coast and about Bahia." The fruit was "a bright yellow drupe with shiny purple-black point," indicating the Raphia palm. Burton's later work includes the diary of the "Pombeiros," the indentured peddlers who were the first Europeans to cross the African continent, at the beginning of the nineteenth century. As with later explorers, food was a critical question, but no oil palms were noted. Palm oil was mentioned once, not as a local product, but as received at Cazembe from a tributary people in the region of Lake Tanganyika.

In Schweinfurth's "Heart of Africa," Elaeis is reported among the Monbutto people, a primitive cannibal tribe in the valley of the Welle River, a northern tributary of the Congo, visited in 1870. "All of their food is prepared by a mixture of oil from the oil palm." Schweinfurth was an eminent botanist, but no distinctive feature of Elaeis was noted, while Raphia was found in great abundance. Later explorers report Raphia oil in extensive use among the natives on the lower reaches of the same river.[1]

The three oil-yielding African palms, Raphia, Borassus and Hyphaene, are widely distributed, from Senegal to Mozambique, the first in swamps or water-courses, the others in dry, open country. A natural habitat for Elaeis has not been recognized. The forest canopy of the coast belt in Liberia and neighboring regions of West Africa is close and continuous, with little undergrowth and no true forest palms except the climbing rattans. The uncut forest does not burn, no humus blanket being formed, the fallen leaves and branches being promptly eaten by termites.

In addition to the oil, some of the tribes obtain palm wine, fiber and building materials from Elaeis, while neigh-

[1] E. Autran, *Ann. Mus. Col.*, Marseille, 1824.

FRUIT CLUSTER
SURROUNDED BY LEAF BASES.

MATURE OIL PALM
GROWING IN NORTHERN HAITI.

boring peoples may have no palms, or only a few. Many missionary settlements, trading posts and colonial stations have established where oil palms are planted and the seeds scattered. The ripe fruits often are carried by the natives as a travel ration, and the seeds thrown aside along the pathways. The seedlings become established in open places, and resist fire. An indigenous palm with the habits and uses of Elaeis probably would have spread across the continent, even in prehistoric times, instead of being so largely restricted to West Africa.

Palm oil is eaten largely with cassava, another Brazilian crop that has spread gradually through tropical Africa, as have maize, tobacco, peanuts, pineapples, papayas, guavas and other food plants that undoubtedly came from America. Several products of American origin now are supplied commercially from the eastern hemisphere, as rubber, quinine, cocaine, cacao, tapioca and cashew-nuts.

O. F. Cook

EXCAVATION OF ANCIENT METEOR CRATERS IN TEXAS

Excavations at the site of three prehistoric meteor craters nine miles southwest of Odessa, Texas, are attracting geological experts and students as well as curious tourists to the sand-hill dotted prairies in the western part of the state.

Recent discovery of two new craters adjacent to the giant pit, which has been under exploration for two years by field crews from the University of Texas, with the assistance of the Work Projects Administration, has heightened interest in the study of the phenomenon.

All three meteors are believed to have crashed to the earth about 40,000 years ago, their terrific speed resulting in a concussion much greater than those caused by the huge bombs of modern warfare.

The main crater, second largest in the United States, has been studied and explored since 1939. Resembling a giant crawfish hole, it is about 500 feet in diameter at the surface and 50 feet deep. The meteor itself, according to Dr. E. H. Sellards, director of the Bureau of Economic Geology of the University of Texas, who is in charge of the project, is believed to be about 164 feet below the bottom of the crater.

One of the newly discovered craters is 70 feet in diameter and about 17 feet deep, and contains as many as "six to seven thousand meteorites with a total weight of about six tons." The theory is that the crater was caused by a closely packed swarm of small meteors, rather than by a single mass breaking into thousands of pieces as it struck.

The other pit is similar in formation but smaller. Since the two new craters were discovered early in September, there has not been time to make an exhaustive study.

Under the direction of Dr. Sellards and Glen Evans, assistant, 35 exploratory drill holes have been put down in and near the main crater. Observations have also been made from additional trenches cut at the sides, and from core drilling.

An elevator shaft is now being sunk in the center of the crater. When it is completed visitors will have an opportunity to actually see the meteor fragments. Present plans are to maintain the site as an educational exhibit open to the public, when excavations are completed.

From observations of the main crater, it has been found that rock strata from as deep as 70 feet was thrown to the surface by the impact of the meteor, that all rock strata in and immediately around the crater were moved from their original positions, and that rock strata forming the crater walls were lifted, broken, folded and faulted.

On the surface the rock debris is

chiefly blocks of limestone often covered and cemented together by caliche. Pits and trenches cut outwards from the rim show that large blocks of shales are included with the limestones. Search among the rock debris enables one to recognize rocks coming from various parts of the geologic section of this locality down to about a depth of 70 feet. The largest of the limestone blocks are three or four feet across. Some of the shale masses are of equal size and larger. Many of the limestone boulders have disintegrated, and the shale persists only when protected by overlying debris. At some places a secondary accumulation of caliche cements the ejected rock, indicating considerable length of time since the crater was formed and the rock thrown out. The maximum thickness of the debris around the rim is now 10 or 12 feet.

At the present time the crater is filled within five or six feet of the level of the surrounding plain. The latest fill consists of fine red incoherent silt with some fine sand. The stratum is lens-shaped, having a thickness of 25 to 30 feet at the center and thinning out to the margins. Some of the sediments are of a degree of fineness such as to indicate that they probably settled from the atmosphere slowly, while the others are coarser and were probably windblown. This stratum of silt and windblown sand, with few pebbles and little or no caliche, readily separated throughout the entire crater from the older, more consolidated and more or less calichified underlying sediments.

Next underlying the silt is a stratum lighter in color which consists in part of silt with which is included pebbles and pieces of rock washed in from the rim of the crater. Caliche has formed in this stratum, resulting in partial cementation. In the central part of the crater this material is 45 to 50 feet thick. The definite line of separation between this and the overlying stratum, together with the difference in texture and origin, suggest that an appreciable time interval separates them.

Some of the rock thrown out by the meteor fell back into the crater. In the

AERIAL VIEW OF THE WEST RIM OF THE METEOR CRATER AT ODESSA

EXCAVATORS BELIEVE THAT THE CRATER WAS CAUSED BY A CLOSELY PACKED SWARM OF METEORS. THE PICTURE WAS TAKEN FROM A HEIGHT OF ABOUT 175 FEET.

central part of the crater this stratum of fragmental rock at the bottom of the crater is 10 or 15 feet thick and is readily distinguishable from finer materials above and below.

Immediately below the fragmental rock there is a stratum which is known as rock flour. In this zone the sand grains were completely shattered by the meteor so that when rubbed they remain only as a coating on the hand. The rock flour is thickest near but somewhat northeast of the center of the crater. From its place of maximum thickness it thins in all directions, forming a lens lying within and not extending to the margins of the crater.

The conclusion reached by Sellards and Evans is that the rock flour is shattered limestone, and that the impact which shattered the sand grains may have been vibration waves.

The land elevation at the crater is near 3,050 feet. The greatest depth at which rock flour was found by drilling is at an elevation of 2946.9 feet, or about 103 feet from the plains surface. The meteorite encountered in drilling lies at an elevation of 2,880 feet, or approximately 67 feet below the lowest known rock flour and about 170 feet from the original surface.

A magnetometer survey, verified by drilling, indicates that the principal meteorite mass or masses lie very nearly under the center of the crater.

The state, through the university, has aided in the cost of supervision, while the WPA has supplied the labor and some supervisory help. The County of Ector has paid the cost of hoist, cable, cage and lumber for construction of the shaft.

J. A. M.

SCIENTIFIC ADVANCE IN GERMANY[1]

Prof. Virchow, in his address before the Congress of German Naturalists, states some facts which show what progress freedom of discussion has made in Germany since the beginning of the present century. "Not perhaps at the dead of night, but still beneath the veil of secrecy, a handfull of *savants* assembled for the first time at Leipsig, at the invitation of Oken. In fact, in 1822, no considerable body of men could come together in Germany, in answer to a public invitation, with the permission of the civil authorities. They could not discuss among themselves scientific questions, no matter how unconnected with the political and national questions of the day. Add to this that other fact, that, if I am not mistaken, it was only in 1861, at the Congress of Naturalists at Spires, that the names of Austrian members could be made public, and then we can appreciate the tremendous change that has been brought about in Vaterland." In the same address Dr. Virchow pays a well-earned tribute of honor to French *savants*. He opposes also the suggestion that has been made by certain German professors, that *Brevets*, or honorary members of French Academies, etc., held by German scientific men, should be sent back, for the reason that a distinguished French botanist had recently declined the honor of being made an associate of the Natural Science Academy of Leipsig.

[1] Printed in *The Scientific Monthly* then called *The Popular Science Monthly* for June 1872—70 years ago.

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Edited by

J. McKEEN CATTELL, F. R. MOULTON AND WARE CATTELL

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NEW BOOKS OF SCIENTIFIC INTEREST

To Discover Mathematics. G. M. MERRIMAN. xi + 435 pp. $3.00. 1942. Wiley.

The purpose of this book is to present informally, by means of a series of essays, the elemental but significant phases of mathematics in order that the reader may comprehend its underlying "utility, philosophy, and beauty." The book is intended for anyone who enjoys reasoning as well as for the mathematician and the student of mathematics.

Matter Energy and Radiation. J. R. DUNNING and H. C. PAXTON. Illustrated. xviii + 668 pp. 1941. McGraw-Hill.

The purpose of this volume, the first in a series of texts prepared for a two-year course in science at Columbia College, is to provide students with an understanding of scientific method and a knowledge of the more fundamental scientific facts and principles.

Benjamin Franklin's Experiments. Ed. by I. BERNARD COHEN. Illustrated. xv + 453 pp. $4.00. Harvard.

This work includes a new edition of Franklin's Experiments and Observations on Electricity together with a four-chapter introduction by Mr. Cohen the purpose of which is to prepare a scientific and biographical background for the presentation of Franklin's papers.

Why We Love Music. C. E. SEASHORE. vi + 82 pp. $1.50. 1941. O. Ditson.

In this book, the author, a technical psychologist, has treated the effects of music from a functional point of view. At the end of each chapter are sections entitled "Thought Review," "Questions," and "Situations to Discuss" which are intended for the use of music clubs and music teachers' associations.

An Introduction to the Study of Algae. V. J. CHAPMAN. Illustrated. x + 387 pp. $3.75. December, 1941. Macmillan.

This book is presented as a short and relatively elementary text-book on psychology. It surveys the field of psychological knowledge from the physiological and ecological as well as from the systematic standpoints. Drawings and diagrams accompany the text.

New Paths in Genetics. J. B. S. HALDANE. 206 pp. $2.50. March, 1942. Harper.

The purpose of this book is to point out the practical application of genetics to research in biochemistry, sociology and medicine. It discusses the genetic basis of various human abnormalities, such as imbecility, color blindness, dwarfism and haemophilia. It is intended for the reader with a general knowledge of the subject.

The Conquest of Bacteria. F. S. TAYLOR. 175 pp. $2.00. 1942. Alliance.

This book tells of the chemical discoveries which conquered disease and of the men behind these conquests. Its purpose is to present the story of chemotherapy, "from salvarsan to sulphapyridine," in such a way as to be understandable to the general reader. There is a brief foreword by Henry E. Sigerist.

Rabies. L. T. WEBSTER. Illustrated. vii + 168 pp. $1.75. March 31, 1942. Macmillan.

This book is intended not only for the dog owner and general public but also for the veterinarian, physician, and student of virus diseases. The author stresses the problems of diagnosis and prevention. Chief attention is directed toward what the author considers the best answers of the day to practical questions.

Sinus. R. C. GROVE. Illustrated. xxxviii + 165 pp. $2.00. 1941. Knopf.

In non-technical language, Dr. Grove explains the structure, position and function of the sinuses, as well as symptoms of sinus diseases and discusses the importance of allergy. He then gives details of various medical and surgical treatments and warns against most forms of self-treatment.

The Advancing Front of Medicine. G. W. GRAY. viii + 425 pp. $3.00. November, 1941. Whittlesey.

The story of the advances which are being made in modern medical research is told in this book. The author discusses the problems and achievements of representative problems, such as allergy, anxiety, cancer and alcoholism.

The University and the Future of America. I. BOWMAN and others. Illustrated. ix + 274 pp. $3.00. September, 1941. Stanford.

The contributors to this symposium have attempted to clarify and partially to solve such questions as where the university should stand in its relation to society, what changes must be made, what potentialities must be developed, what fields should be emphasized.

Our World and Science. S. R. POWERS, E. F. NEUNER, H. B. BRUNER, J. H. BRADLEY. Illustrated. vii + 653 pp. $1.76. 1941. Ginn.

This textbook for general science courses presents science as an adventure. The eight units discuss astronomy, water, weather, life, geology, industry, health and conservation. Its theme is the dependence of living things on each other and their environment.

Self-Analysis. K. HORNEY. 309 pp. 1942. $3.00. Norton.

Dr. Horney's purpose in writing this book was to offer the discoveries of psychoanalysis to the individual for use in dealing with his own problems. The author discusses the driving forces in the neuroses, the different stages of psychoanalytical understanding, the patient's share in the psychoanalytical process, and the like.

Studies in the History of Science. E. A. SPEISER and others. Illustrated. 123 pp. $1.50. May, 1941. Pennsylvania.

This is a collection of lectures given by eight men of science at the Bicentennial Conference of the University of Pennsylvania. The lectures have a wide variety of subject matter, ranging from "Medieval Medicine" to "The Mathematical Way of Thinking."

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RECENT BOOKS OF SCIENTIFIC INTEREST

The Engineering Profession. T. J. HOOVER and J. C. L. FISH. Illustrated. xii + 441 pp. $5.00. August, 1941. Stanford.

The qualifications and duties of the professional engineer and his habit of mind are described in this book. It is written primarily for young men contemplating a career in engineering. Points of technology are used only by way of illustration.

Life Science. M. W. DE LAUBENFELS. Illustrated. i + 320 pp. $3.75. 1941. Laubenfels.

This book is designed to be a general survey of all fields of biology. Each chapter covers one branch of the subject, emphasis being placed upon the interrelationships between the various fields. One-thousand-twenty-two illustrations accompany the text. It is intended for those who do not intend to specialize in biology.

Foundations for a Science of Personality. A. ANGYAL. xii + 398 pp. $2.25. 1941. Commonwealth Fund.

This book constitutes an analysis of the various facets of human nature. The author considers the physiological, psychological, and environmental modes of operation of the organism as aspects of a unitary process; he emphasizes "the organism as a whole."

Hell's Bells. A. S. PEARSE. 121 pp. $2.00. 1941. Seeman Printery.

The author, a well-known biologist, considers in essay form some of the problems of everyday living from the viewpoint of the scientist. His topics are society, sex, love, fear, faith, adventure, conservatism, laws, education, human levels, being a member, ideals, trade, knowledge, success and the future.

Between Physics and Philosophy. P. FRANK. 238 pp. $2.75. 1941. Harvard.

The author attempts to clarify the fundamental principles underlying the factual findings of modern science. Some of the ideas considered are: The philosophy of the Austrian physicist, Ernest Mach; the notion of "length" in Einstein's theory of relativity; Bohr's notion of "complementarity" in modern quantum theory.

Your Teeth: Their Past, Present and Probable Future. P. J. BREKHUS. Illustrated. xvii + 255 pp. $2.50. 1941. Minnesota.

A dental practitioner, teacher and investigator tells the history of dentistry and gives a general discussion, excluding technicalities, of teeth—their decay abnormalities, etc. He favors the theory that decreased functioning is largely responsible for deterioration.

Glass: The Miracle Maker. C. J. PHILLIPS. Illustrated. xii + 424 pp. $4.50. 1941. Pitman.

The story of the history, manufacture, physical and chemical properties of glass and its applications are here collected from scattered sources. It is intended for the architect, engineer, industrial designer and layman who are interested in glass and its future possibilities in industry.

The University and the Future of America. I. BOWMAN and others. Illustrated. ix + 274 pp. $3.00. September, 1941. Stanford.

Fifteen men of experience in university activity in various fields—science, education, medicine, law, psychology, sociology and economics—have contributed to this volume an account of what they believe is the place of the universities in the future of America.

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CHEMISTRY. By GERALD WENDT, formerly Dean, School of Chemistry and Physics, The Pennsylvania State College. 300 pages; 5⅜ by 8⅜; illustrated; $2.25.

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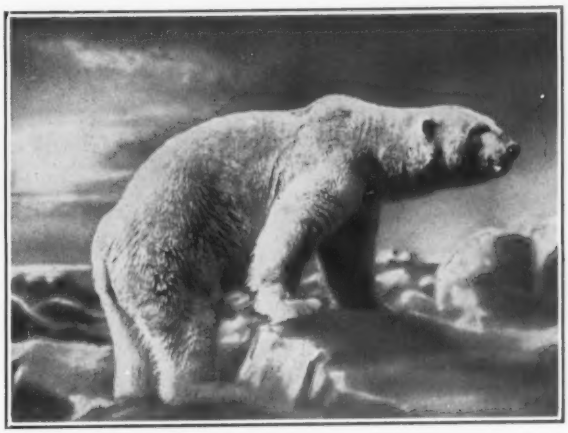

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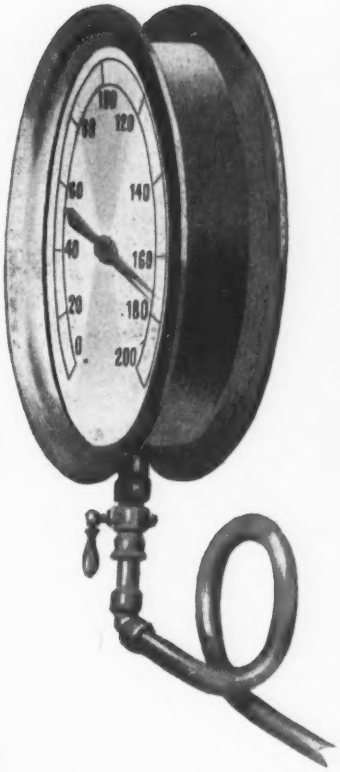

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